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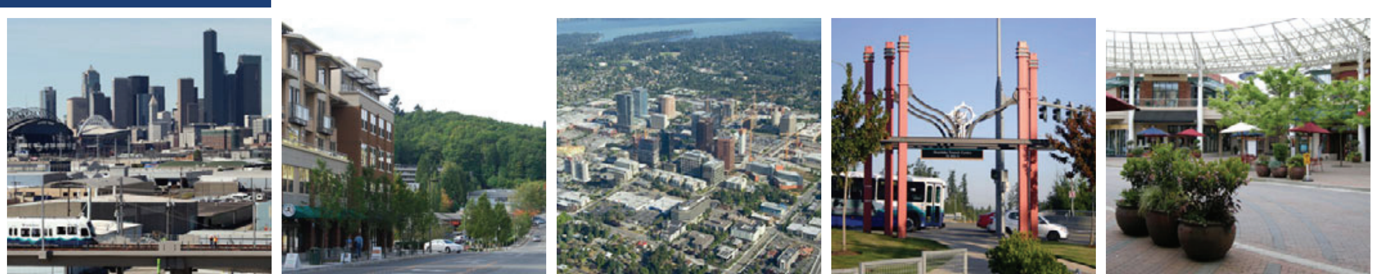
EAST LINK PROJECT

DRAFT ENVIRONMENTAL IMPACT STATEMENT

Appendix H2

Noise and Vibration Technical Report



SEATTLE MERCER ISLAND BELLEVUE OVERLAKE REDMOND

SOUNDTRANSIT

CENTRAL PUGET SOUND
REGIONAL TRANSIT AUTHORITY

Washington State Department of Transportation

U.S. Department of Transportation Federal Transit Administration

December 2008

SOUND TRANSIT EAST LINK PROJECT

Appendix H2

Noise and Vibration Technical Report

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Contents

Appendixes

Exhibits

Tables

Acronyms and Abbreviations

ANSI	American National Standards Institute
CFR	Code of Federal Regulations
DAT	digital audio tape
dB	decibel
dBA	A-weighted decibel
DNL	Day-Night Equivalent Sound Level (also Ldn)
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
HVAC	heating ventilation and air conditioning
Hz	Hertz
HUD	Department of Housing and Urban Development+
HVAC	heating, ventilation, air conditioning
I-90	Interstate 90
I-405	Interstate 405
Ldn	24-hour, time-averaged, A-weighted sound level (day-night)
Leq	equivalent continuous sound level
Lmax or Lm	maximum noise level
Lv	vibration velocity level
LRV	light rail vehicle
mph	miles per hour
NIOSHA	National Institute for Occupations Safety and Health
NIST	National Institute of Standards and Technology
OSHA	Occupation and Health and Safety Administration
PPV	peak particle velocity
rms	root mean square
SR	state route
TDA	tire-derived aggregate
TNM	traffic noise model
V	velocity

VdB	vibration decibels
WAC	Washington Administrative Code
WSDOT	Washington State Department of Transportation

1.0 Introduction and Summary

This technical report presents a noise and vibration impact study for the Sound Transit East Link Project. The objective of the study was to assess the potential noise and vibration impacts of the planned light rail transit project.

Section 1 of this report describes the background and results of the assessment. Section 2 provides a discussion of environmental noise and vibration basics, and Section 3 describes the existing noise and vibration conditions and measurement results. The criteria used to assess noise and vibration impacts are presented in Section 4, and projections of future noise and vibration conditions are described in Section 5. Section 6 summarizes the impact assessment, and Section 7 outlines potential mitigation measures. Appendix A includes noise and vibration impacts by affected alternative; Appendix B includes vibration measurement site photographs; Appendix C and Appendix D include detailed noise and vibration measurement data, respectively; and Appendix E contains the detailed noise impact assessment data.

1.1 Background

The proposed project consists of constructing and operating an 18-mile light rail system, known as East Link, between Seattle and Redmond. This system would connect with Sound Transit's Central Link at the International District/ Chinatown Station; travel east across Lake Washington via Interstate 90 (I-90) to Mercer Island, Downtown Bellevue, and Overlake; and terminate in Downtown Redmond. For evaluation purposes, the East Link study area was divided into five segments along distinct geographic boundaries. There are 19 alternatives spread over the following 5 segments:

Segment A, Interstate 90

- I-90 Alternative (A1)

Segment B, South Bellevue

- Bellevue Way Alternative (B1)
- 112th SE At-Grade Alternative (B2A)
- 112th SE Elevated Alternative (B2E)
- 112th SE Bypass Alternative (B3)
- BNSF Alternative (B7)

Segment C, Downtown Bellevue

- Bellevue Way Tunnel Alternative (C1T)
- 106th NE Tunnel Alternative (C2T)
- 1108th NE Tunnel Alternative (C3T)
- Couplet Alternative (C4A)
- 112th NE Elevated Alternative (C7E)
- 110th NE Elevated Alternative (C8E)

Segment D, Bel-Red/Overlake

- NE 16th At-Grade Alternative (D2A)
- NE 16th Elevated Alternative (D2E)
- NE 20th Alternative (D3)
- SR 520 Alternative (D5)

Segment E, Downtown Redmond

- Redmond Way Alternative (E1)
- Marymoor Alternative (E2)
- Leary Way Alternative (E4)

Within Segments D and E, there are a total of four alternative sites for a new light rail maintenance facility:

- 116th Maintenance Facility (MF1)
- BNSF Maintenance Facility (MF2)
- SR 520 Maintenance Facility (MF3)
- SE Redmond Maintenance Facility (MF5)

The build alternatives are made up of a range of light rail routes and stations, some with adjoining park-and-ride lots. Maintenance facility alternatives are evaluated separately from the alternative routes and stations.

1.2 Summary of Results

1.2.1 Noise Impact Assessment

The results of the noise analysis indicate that the environment in the project vicinity is already affected by existing noise from traffic on major highways and local roads and from general community noise. Based on Federal Transit Administration (FTA) criteria, it is predicted that without mitigation, the East Link Project would cause noise impacts at the locations listed in Table 1. Detailed information regarding the impacts can be found in Section 6.1 and Appendix D of this report. A number of noise mitigation measures would be considered for the impacts. The two most likely methods of noise mitigation would be noise barriers and sound insulation. Sound insulation treatments are typically applied to buildings in areas where barriers would not be effective. The final mitigation design will depend on more detailed noise analysis during final design; however, all noise impacts on interior areas can be mitigated.

It is important to note that for those locations mitigated with sound insulation, the exterior noise levels may still exceed the criteria. For most locations, such exterior areas would occur on balconies, back or side yards, and in a few circumstances, front yards. The actual change in noise levels at most of these locations would typically be 3 A-weighted decibels (dBA) or less, which is not considered noticeable by humans.

In addition to the required noise analyses, Sound Transit conducted an analysis for select stations that are located within or over freeway corridors. These analyses are not reflected in Table 1 below. These unique locations present the potential for noise impacts to light rail patrons; however, there are no standards for this type of receptor. With sound barriers at some of these stations, projected noise levels at these station locations were found to be within the range identified by the Environmental Protection Agency (EPA) as appropriate for communication at close distances.

TABLE 1
Summary of Potential Noise Impacts

Alternative	Connection Option	Moderate Light Rail Impacts		Severe Light Rail Impacts		Traffic Noise Impacts	
		Before Mitigation	After Mitigation	Before Mitigation	After Mitigation	Before Mitigation	After Mitigation
Segment A							
A1, I-90	--	None		None		None	
Segment B							
B1, Bellevue Way	--	None		3 SF units	None	41 SF and 39 MF residences	Exterior only- 54 SF and MF units
B2A, 112th SE At-Grade	--	None		None		20 SF residences	None
B2E, 112th SE Elevated	--	None		None		None	
B3, 112th SE Bypass	--	None		None		20 SF residences	None
B7, BNSF	--	59 MF units along I-405	None	39 MF units	None	None	
Segment C							
C1T, Bellevue Way Tunnel		12 MF units	None	None		21 MF units	Exterior only-21 MF units
C2T, 106th NE Tunnel	B2A, 112th SE At-Grade	12 MF units	None	None		None	
	B2E, 112th SE Elevated	12 MF units	None	18 Hotel rooms 2 SF units 4 MF units	None	None	
	B3, 112th SE Bypass B7, BNSF	12 MF units 4 Hotel rooms	None	None		None	
C3T, 108th NE Tunnel	B2A, 112th SE At-Grade	None		None		None	
	B2E, 112th SE Elevated	None		18 Hotel rooms 2 SF units 4 MF units	None	None	
	B3, 112th SE Bypass B7, BNSF	4 Hotel rooms	None	None		None	

TABLE 1
Summary of Potential Noise Impacts

Alternative	Connection Option	Moderate Light Rail Impacts		Severe Light Rail Impacts		Traffic Noise Impacts	
		Before Mitigation	After Mitigation	Before Mitigation	After Mitigation	Before Mitigation	After Mitigation
C4A, Couplet	B2A, 112th SE At-Grade	12 MF units	Exterior only-12 MF units	None		None	
	B2E, 112th SE Elevated	None		6 MF units	Exterior only-6 MF units	None	
	B3, 112th SE Bypass B7, BNSF	4 Hotel rooms	None	None		None	
C7E, 112th NE Elevated	B2A, 112th SE At-Grade	None		2 SF units 10 MF units	None	None	
	B2E, 112th SE Elevated	None		2 SF units 4 MF units	None	None	
	B3, 112th SE Bypass B7, BNSF	4 Hotel rooms	None	None		None	
C8E, 110th NE Elevated	B3, 112th SE Bypass B7, BNSF	80 MF units 3 SF units 4 Hotel rooms	Exterior only - 80 MF units	None		None	
Segment D							
D2A, NE 16th At-Grade D2E, NE 16th Elevated D3, NE 20th	All	None		None		None	
D5, SR 520	All	10 MF units	None	None		None	
Segment E							
E1, Redmond Way	N/A	26 MF units	None	None		None	
E2, Marymoor E4, Leary Way	N/A	None		None		None	

SF = single family
MF = Multifamily

1.2.2 Vibration Impact Assessment

Based on FTA criteria, it is predicted that without mitigation, the East Link Project would cause some level of vibration and ground-borne noise impacts at the locations listed in Table 2. However, these impacts would be related to annoyance effects and not to building damage effects. Section 6.2 includes detailed information regarding the impacts, and Section 7.5 discusses proposed mitigation measures. Although most impacts can be mitigated, there may be some residual impacts remaining after mitigation.

There are a number of options available for the mitigation of vibration impacts. The most common method is ballast mats and high compliance track fasteners. Ballast mats consist of pads made of rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. Because the vibration reduction provided by ballast mats is limited at lower frequencies, their effectiveness is dependent on the frequency content of the vibration. Track fasteners can be used to provide vibration isolation between rails and concrete slabs for direct fixation track on elevated structures or in tunnels. Mitigation measures will be evaluated in more detail during final design, and the most appropriate measures would be selected based on feasibility and cost effectiveness.

TABLE 2
Summary of Vibration Impacts

Alternative and Connection		Before Mitigation		After Mitigation	
		Number of Vibration Impacts	Number of Ground-Borne Noise Impacts[a]	Number of Vibration Impacts	Number of Ground-Borne Noise Impacts
Segment A					
A1, I-90		0	25 SF	0	0
Segment B					
B1, Bellevue Way		1 SF	0	0	0
B2A, 112th SE At-Grade; B2E, 112th SE Elevated; B3, 112th SE Bypass; and B7, BNSF		0	0	0	0
Segment C					
C1T, Bellevue Way Tunnel	--	1 SF 1 Hotel Meydenbauer Center Theater	1 SF Meydenbauer Center Theater	0	0
C2T, 106th NE Tunnel	B2A, 112th SE At-Grade	Meydenbauer Center Theater	Meydenbauer Center Theater	0	0
	B2E, 112th SE Elevated	Meydenbauer Center Theater	1 SF Meydenbauer Center Theater	0	0
	B3, 112th SE Bypass; B7, BNSF	1 Hotel Meydenbauer Center Theater	Meydenbauer Center Theater	1 Hotel	0
C3T, 108th NE Tunnel	B2A, 112th SE At-Grade	0	12 SF	0	0
	B2E, 112th SE Elevated	0	2 SF	0	0
	B3, 112th SE Bypass B7, BNSF	1 Hotel	1 SF	1 Hotel	0
C4A, Couplet	B2A, 112th SE At-Grade B2E, 112th SE Elevated	6 MF 1 SF	0	2 MF	0
	B3, 112th SE Bypass B7, BNSF	6 MF 1 SF 1 Hotel	0	2 MF 1 Hotel	0

TABLE 2
Summary of Vibration Impacts

Alternative and Connection		Before Mitigation: Number of Vibration Impacts	Before Mitigation: Number of Ground-Borne Noise Impacts[a]	After Mitigation: Number of Vibration Impacts	After Mitigation: Number of Ground-Borne Noise Impacts
C7E, 112th NE Elevated	B2A, 112th SE At-Grade B2E, 112th SE Elevated	0	0	0	0
	B3, 112th SE Bypass B7, BNSF	1 Hotel	0	1 Hotel	0
C8E, 110th NE Elevated	B3, 112th SE Bypass B7, BNSF	3 MF 2 SF 2 Hotels	0	1 MF 1 Hotel	0
Segment D					
D2A, NE 16th At-grade D2E, NE 16th Elevated D3, NE 20th D5, SR 520		0	0	0	0
Segment E					
E1, Redmond Way E2, Marymoor		3 SF	0	1 SF	0
E4, Leary Way		1 MF 1 SF 1 Hotel	0	0	0

[a] Ground-borne noise is only assessed for tunnel locations.

2.0 Environmental Noise and Vibration Basics

2.1 Noise Fundamentals and Descriptors

What humans perceive as sound is a series of continuous air pressure fluctuations superimposed on the atmospheric pressure that surrounds us. The amplitude of fluctuation is related to the energy carried in a sound wave; the greater the amplitude, the greater the energy, and the louder the sound. The full range of sound pressures encountered in the world is so great that it is more convenient to compress the range by using a logarithmic scale, resulting in the fundamental descriptor used in acoustics, the sound pressure level, which is measured in decibels (dB). When sounds are unpleasant, unwanted, or disturbingly loud, we tend to classify them as noise.

Another aspect of sound is the quality described as its pitch. Pitch of a sound is established by the frequency, which is a measure of how rapidly a sound wave fluctuates. The unit of measurement is cycles per second, called hertz (Hz). When a sound is analyzed, its energy content at individual frequencies is displayed over the frequency range of interest, usually the range of human audibility from 20 Hz to 20,000 Hz. This display is called a frequency spectrum.

Sound is measured using a sound-level meter with a microphone designed to respond accurately to all audible frequencies. However, the human hearing system does not respond equally to all frequencies. Low-frequency sounds below about 400 Hz are progressively and severely attenuated, as are high frequencies above 10,000 Hz. To approximate the way humans interpret sound, a filter circuit with frequency characteristics similar to the human hearing mechanism is built into sound-level meters. Measurements with this filter enacted are called A-weighted sound levels, expressed in A-weighted decibels (dBA). Community noise is usually characterized in terms of the A-weighted sound level. Exhibit 1 illustrates the A-weighted levels of common sounds.

The range of human hearing extends from about 0 dBA for young healthy ears (that have not been exposed to loud noise sources) to about 140 dBA. When sounds exceed 110 dBA, there is a potential for hearing damage, even with relatively short exposures. In quiet suburban areas far from major freeways, the noise levels during the late night hours will drop to about 30 dBA. Outdoor noise levels lower than this only occur in isolated areas where there is a minimum even of natural noises, such as leaves blowing in the wind, crickets, or flowing water.

Another characteristic of environmental noise is that it is constantly changing. The noise-level increase when a train passes is an example of a short-term change. The lower average noise levels occur during nighttime hours, when activities are at a minimum, and higher noise levels during daytime hours are caused by daily patterns of noise-level fluctuation. The instantaneous A-weighted sound level is insufficient to describe the overall acoustic “environment.” Thus, it is common practice to condense the fluctuating noise levels into a single number, called the “equivalent” sound level (Leq). Leq can be thought of as the steady sound level that represents the same sound energy as the varying sound levels over a specified time period (typically 1 hour or 24 hours). Often the Leq values over a 24-hour period are used to calculate cumulative noise exposure in terms of the Day-Night Equivalent Sound Level (Ldn, also abbreviated DNL), which is defined as the 24-hour Leq but with a 10-dB penalty assessed to noise events occurring at night (defined as 10 p.m. to 7 a.m.). The effect of this penalty is that any event during the nighttime hours is equivalent to 10 events during the daytime hours. This strongly weights Ldn toward nighttime noise to reflect most people being more easily annoyed by noise during the nighttime hours, when background noise is lower and most people are resting.

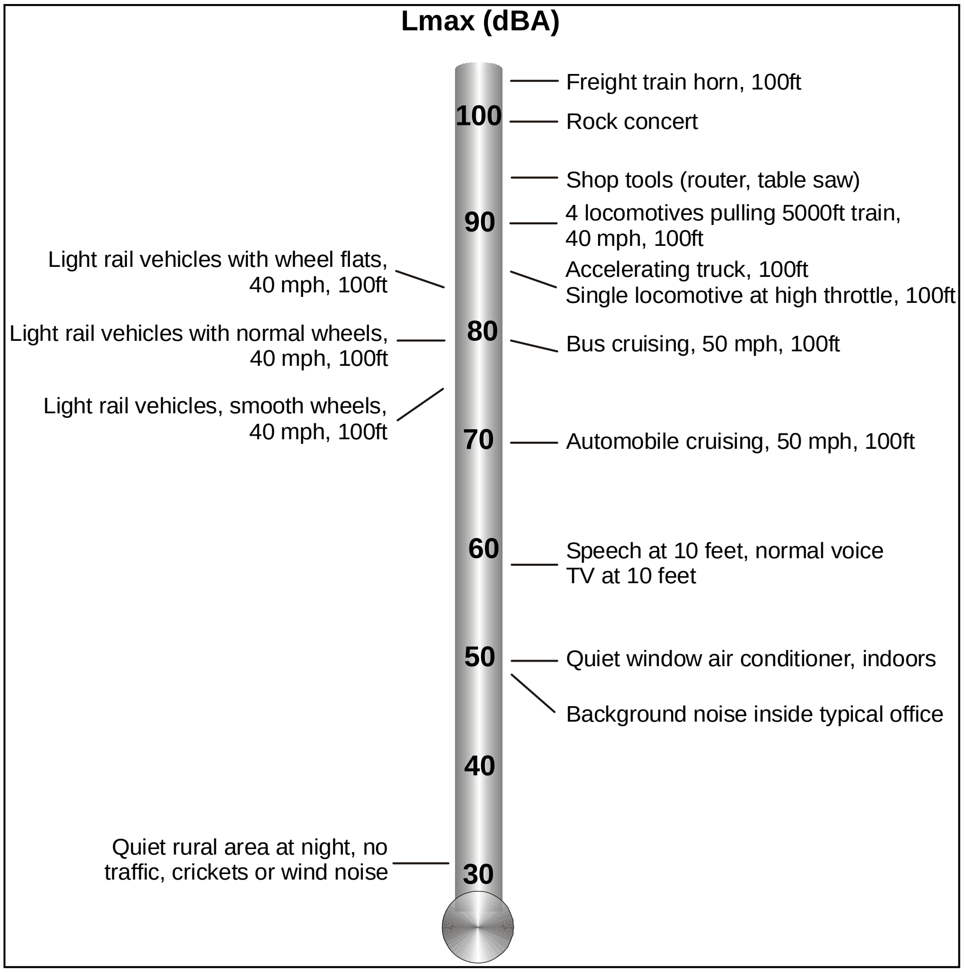


EXHIBIT 1
Comparison of Various Noise Levels

Environmental impact assessments for high-capacity transit projects in the United States typically use Ldn to describe the community noise environment at residential locations. Studies of community response to a wide variety of noises indicate that Ldn is a good measure of the noise environment. Efforts to derive measures that are better correlated to community response have not been successful, although there are still efforts in the acoustical community to develop improved measures. Exhibit 2 defines typical community noise levels in terms of Ldn. Most urban and suburban neighborhoods are usually in the range of Ldn 50 dBA to 70 dBA. An Ldn of 70 dBA is a relatively noisy environment that might be found at buildings on a busy surface street, close to a freeway or near a busy airport and would usually be considered unacceptable for residential land use without special measures taken to enhance outdoor-indoor sound insulation. Residential neighborhoods that are not near major sound sources are usually in the range of Ldn 55 dBA to 60 dBA. If there is a freeway or moderately busy arterial nearby, or any nighttime noise, Ldn is usually in the range of 60 to 65 dBA.

Ldn is the designated noise metric of choice for many federal agencies, including the Department of Housing and Urban Development (HUD), Federal Aviation Administration (FAA), FTA, and EPA. Although Ldn does have recognized limitations and there is still considerable discussion within the acoustical community about whether improved metrics are possible, there is general consensus that Ldn, or similar energy-based metrics, are the best available means of describing community noise environments. Most federal and state agency criteria for noise

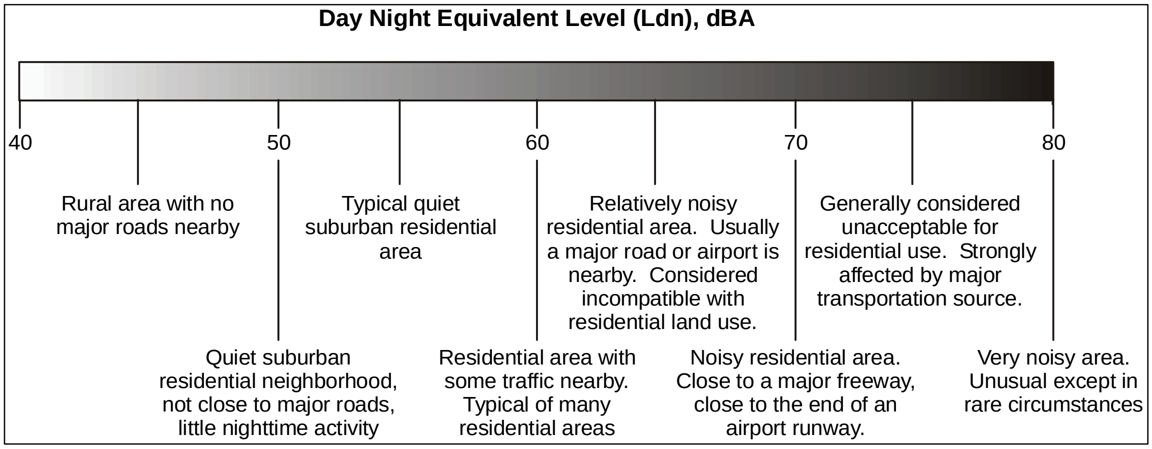


EXHIBIT 2
Examples of Typical Outdoor Noise Exposure

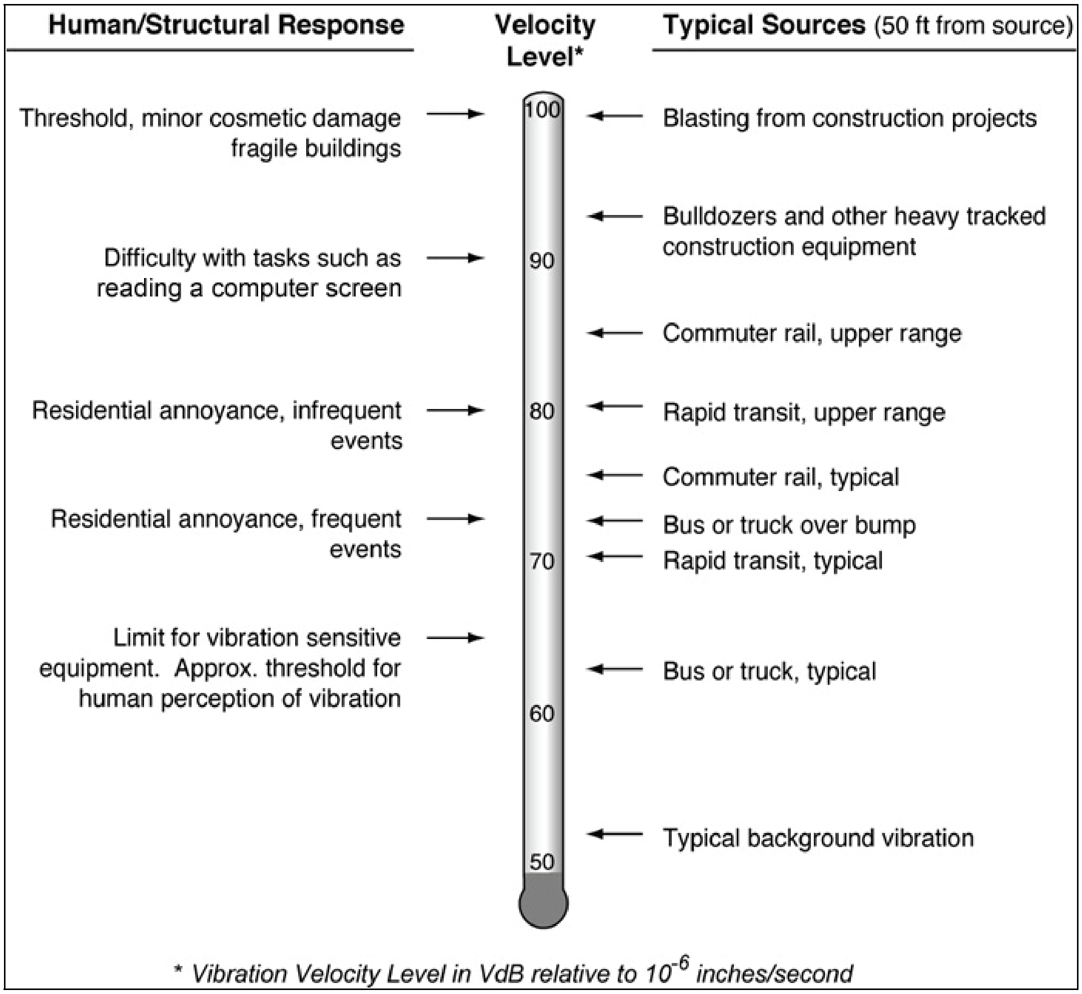


EXHIBIT 3
Typical Ground-Borne Vibration Levels and Human/Structural Response

impacts are based on some measurement of noise energy. For example, the FAA and HUD use Ldn, and the Federal Highway Administration (FHWA) uses peak hour Leq. The noise impact criteria applicable to residential areas, and included in the FTA manual *Transit Noise and Vibration Impact Assessment*, use both Leq and Ldn to characterize community noise.

The Washington State Administrative Code uses the noise level descriptor Lnn in their noise control ordinance, which is applicable to the noise analysis of ancillary facilities such as park-and-ride lots and maintenance facilities, as well as construction activities. The sound level descriptor Lnn is defined as the sound level exceeded "n" percent of the time. For example, the L50 is the sound level exceeded 50 percent of the time; therefore, during a 1-hour measurement, an L50 of 60 dBA means the sound level equaled or exceeded 60 dBA for 30 minutes during that hour.

2.2 Vibration Fundamentals and Descriptors

Ground-borne vibration is the oscillatory motion of the ground about some equilibrium position, which can be described in terms of displacement, velocity, or acceleration. Displacement refers to the distance an object moves away from its equilibrium position. Velocity refers to the rate of change in displacement or the speed of this motion. Acceleration refers to the time rate of change in the velocity of the object. At any given frequency of oscillation, vibration displacement, velocity, and acceleration are related. However, the relationship between these descriptors is complex and can vary greatly in different situations. Therefore, the relationship between the overall vibration levels in terms of these descriptors depends on the frequency content of the vibration energy.

Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. One reason for this is that most sensors used for measuring ground-borne vibration are designed to provide output signals proportional to either velocity or acceleration. Even more important, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration. Because sensitivity to vibration typically corresponds to a constant level of vibration-velocity amplitude within the low-frequency range that is of most concern for environmental vibration (i.e., roughly 5 to 100 Hz), vibration velocity is used in this analysis as the primary measure to evaluate the effects of vibration.

There are several different measures used to quantify vibration amplitude. One of the most common is the peak particle velocity (PPV), defined as the maximum instantaneous positive or negative peak of the vibratory motion. PPV is often used to monitor blasting vibration because it is related to the stresses experienced by building components. Although PPV is appropriate for evaluating the potential for building damage, it is less suitable for evaluating human response, which is better related to an average vibration amplitude. Because the net average of a vibration signal about its equilibrium position is zero, the root mean square (rms) amplitude is often used to describe the "smoothed" vibration amplitude. The rms amplitude is defined as the square root of the average of the squared amplitude of the signal and is typically evaluated over a 1-second period of time.

Although vibration velocity is normally described in units of inches per second in the United States, the decibel notation, which acts to compress the range of numbers required to describe vibration, can also be used. In this notation, the vibration magnitude can be expressed in terms of velocity level, in decibels, defined as follows:

$$Lv = 20\log_{10}(v/v_{ref}), \text{ VdB} \qquad \text{where: } v = \text{rms velocity, inches/second}$$
$$v_{ref} = 1\text{x}10^{-6} \text{ inches/second}$$

Thus, the descriptor used for this assessment of ground-borne vibration is the rms vibration velocity level, Lv, expressed in vibration decibels (VdB) relative to one micro-inch per second. Exhibit 3 illustrates typical ground-borne vibration levels for common sources, as well as human and structural response to ground-borne vibration. As shown, the range of interest is from approximately 50 VdB to 100 VdB (i.e., from imperceptible background vibration to the threshold of damage). Although the threshold of human

perception to vibration is approximately 65 VdB, annoyance does not usually occur unless the vibration exceeds 70 VdB.

When ground-borne vibrations propagate from transit vehicles to nearby buildings, the floors and walls of the building structure will respond to the motion and may resonate at natural frequencies. The vibration of the walls and floors may cause perceptible vibration, rattling of items such as windows or dishes on shelves, or a rumbling noise. The rumble is the noise radiated from the motion of the room surfaces. In essence, the room surfaces act like a giant loudspeaker. This is called ground-borne noise.

The potential annoyance of ground-borne noise is often assessed using the A-weighted sound level, although there are potential problems in using the A-weighted sound level to characterize low-frequency ground-borne noise. Human hearing is non-linear, which causes sounds with substantial low-frequency content to seem louder than broadband sounds that have the same A-weighted level. This is accounted for by setting A-weighted impact criteria limits lower for ground-borne noise than would be the case for broadband noise.

3.0 Existing Conditions

The project corridor was examined to identify noise-sensitive locations and to select locations where noise monitoring would be performed. The following sections describe the land use along the project corridor, the existing noise-level measurements and the current noise sources in the project corridor. While a more detailed presentation of land use can be found in Section 4.3, Land Use of the East Link Draft Environmental Impact Statement (EIS), the following land uses are summarized for their potential sensitivity to noise and vibration. Most identified land uses are sensitive to both noise and vibration. The exceptions include outdoor parks, which may be noise sensitive, depending on usage, but are not vibration sensitive, and vibration sensitive equipment (such as an MRI), which is not sensitive to noise. Exhibits 4 through 9 show the different alternatives, noise monitoring locations, and existing land uses.

3.1 Land Use

3.1.1 Segment A

The Central Link connection to the East Link Project corridor is located in the International/Chinatown District, an area within walking distance to Downtown Seattle and Pioneer Square to the north, sports stadiums to the west and south, and an industrial area also to the south. Land use near the connection is mainly commercial; however, the route is already in the existing transit tunnel and therefore would not have the potential to affect adjacent land uses. The route continues along the 5th Avenue ramps of I-90, remaining in the existing I-90 corridor to the I-90 tunnel portals. I-90 crosses I-5, passing by predominantly commercial uses to the north and large greenbelt parks, residential and commercial uses on Beacon Hill to the south. Land use along this section of the route is mainly commercial until 12th Avenue S, where there is a large group of single-family and multifamily residences along Sturgus Avenue S. Judkins Park and Playfield is located to the north of the route just before the Mt. Baker tunnel portals. There are also several single-family residences and the Sam Smith Park located above the Mount Baker Tunnel. The route transitions from the tunnel to the floating bridge in an area that is primarily single-family residential.

The I-90 corridor and light rail routes are well below grade across Mercer Island. At the western end of the island, near the I-90 bridge and tunnel, land use is residential with a park on and around the tunnel lid. Most residences in this area are more that 300 feet from the proposed light rail route.

Land use near the proposed Mercer Island Station includes a new park-and-ride structure and single-family residences to the north and a large multifamily building to the east. West and south of the station are the highway and connector roadways that lead to the I-90 on- and off-ramps. Also to the south of the station are mid-rise mixed-use developments that either are under construction or newly opened.

At the eastern end of Mercer Island, land use is primarily single-family residential with some commercial use to the south of I-90.

3.1.2 Segment B

Land use in Segment B consists primarily of residences and parks, with some institutional and commercial uses. Land use in the southern end of Segment B, near Lake Washington, includes single-family residences and Enatai Beach Park. Along the west side of the Bellevue Way, land use is entirely residential from SE 34th Street to the intersection at 112th Avenue SE, and Mercer Slough Nature Park dominates the east side. For the remainder of the length of Bellevue Way, between 112th Avenue SE and Segment C, land use is also primarily residential; however, there are also several churches and commercial structures and a daycare in this portion of Segment B.

The Frederick Winters House, a historic structure used for non-residential uses, is located along the east side of Bellevue Way, adjacent to the Mercer Slough Nature Park. Along 112th Avenue SE, land use to the west is entirely single- and multifamily residential; to the east, land use is commercial between the intersection of Bellevue Way and SE 8th Street, transitioning to mixed commercial and hotel use from SE 8th Street to Segment C at SE 6th Street. Land use along the BNSF Alternative (B7) is primarily parkland north of the route, with some multifamily and commercial land uses where the alternative transitions to the BNSF Railway corridor. Land use along the BNSF corridor includes multifamily residential and some commercial between SE 32nd Street and SE 8th Street.

3.1.3 Segment C

Land use in the southern section of Segment C includes the Surrey Downs residential area and park, transitioning to commercial and office use at Main Street. Land uses along Bellevue Way and 112th Avenue SE south of Main Street are similar as in Segment B. There are some mixed-use buildings in Downtown Bellevue, with commercial uses on the ground floors and residential units on the upper floors. The Downtown Park is located near the Bellevue Way Tunnel Alternative (C1T) west of Bellevue Way. Some Segment C alternatives pass by the Bellevue City Hall, the Meydenbauer Convention Center, the Bellevue Regional Library, and Ashwood Park.

In addition, residential land uses were identified along the northern edge of Downtown Bellevue. There are several multifamily residential units along 110th Avenue NE and 112th Avenue NE, near NE 12th Street. The Bellevue Regional Library and Ashwood Park are also located near NE 12th Street. McCormick Park is located on the north side of NE 12th Street, between 112th Avenue NE and 106th Place NE. North of McCormick Park, land use is primarily single- and multifamily residential.

Noise-sensitive land uses east of I-405 include Overlake Hospital, Group Health Medical Center, and a broad range of medical offices supporting the hospital. There is also a multifamily residential area at the north end of Lake Bellevue, along NE 12th Street.

3.1.4 Segment D

Segment D land use is mainly commercial and light industrial, including retail, distribution facilities, and office spaces. Single- and multifamily residences were identified along 116th Avenue NE, north of NE 12th Street. There is also a multifamily residential structure along NE 21st Place, just south of State Route (SR) 520. No other residential land use was identified near the light rail alternatives between Segment C and Overlake Center.

Noise sensitive land use in the Overlake area includes an assisted living facility. In addition, Eastside Hospital property was recently sold and is being redeveloped to a mixed residential and commercial use facility. The remaining land use in Segment D is commercial, and includes the Microsoft Campus and several retail complexes.

3.1.5 Segment E

All light rail alternatives in Segment E begin at the Overlake Transit Center in the commercial area near the NE 40th Street SR 520 overpass. North of NE 51st Street, land use changes to single-family residential. Most residences in this area are located behind a noise wall along SR 520. Land use remains single-family residential to the West Lake Sammamish Parkway exit, where land use changes to multifamily residential, park, and commercial land uses south of Downtown Redmond. The Marymoor Alternative (E2) follows SR 520 just north of Marymoor Park, while the Redmond Way (E1) and Leary Way (E2) alternatives pass through multifamily and commercial areas adjacent to NE Redmond Way and Leary Way.

Land use in the Downtown Redmond area varies but is mainly commercial and retail, with some mixed-use buildings with residential use on their upper floors. There are also several hotels in Downtown Redmond, including the Residence Inn on 164th Avenue NE and the Redmond Inn on Redmond Way near the proposed SE Redmond Station.

3.2 Noise Measurements

The existing noise environment was characterized through on-site inspections and on-site noise monitoring. Monitoring was performed at 46 locations, including 13 long-term (24-hour) and 33 short-term (20-minute) sites. Exhibits 4 through 8 show the locations of the noise monitoring sites. The exhibits also show land use in the project vicinity and light rail alternatives. Selection of monitoring sites is based on land use, existing noise sources, alternative proximity and profile type, and ability to represent nearby noise-sensitive land uses.

All noise measurements were taken in accordance with the American National Standards Institute (ANSI) procedures for community noise measurements. Measurement locations were at least 5 feet from any solid structure to prevent acoustical reflections and at a height of 5 feet off the ground as required by ANSI standards. The equipment used for noise monitoring included Bruel & Kjaer Type 2238 Sound Level Meters and a Larson Davis Model 820 Sound Level Meter. The meters were calibrated before and after measurement periods using a sound-level calibrator. Complete system calibration is performed on an annual basis by an accredited testing laboratory. The laboratory system calibration is traceable to the National Institute of Standards and Technology (NIST). The systems meet or exceed the requirements for an ANSI Type 1 noise measurement system.

For long-term monitoring locations, the Ldn was calculated using logarithmic energy averaging for the 24-hour data with a 10-dBA penalty for noise measured between 10 p.m. and 7 a.m. For short-term monitoring locations, the Ldn levels were predicted using formulas in the FTA manual *Transit Noise and Vibration Impact Assessment* and comparison to other nearby long-term noise monitoring sites.

The following sections describe the existing noise environment by project segments.

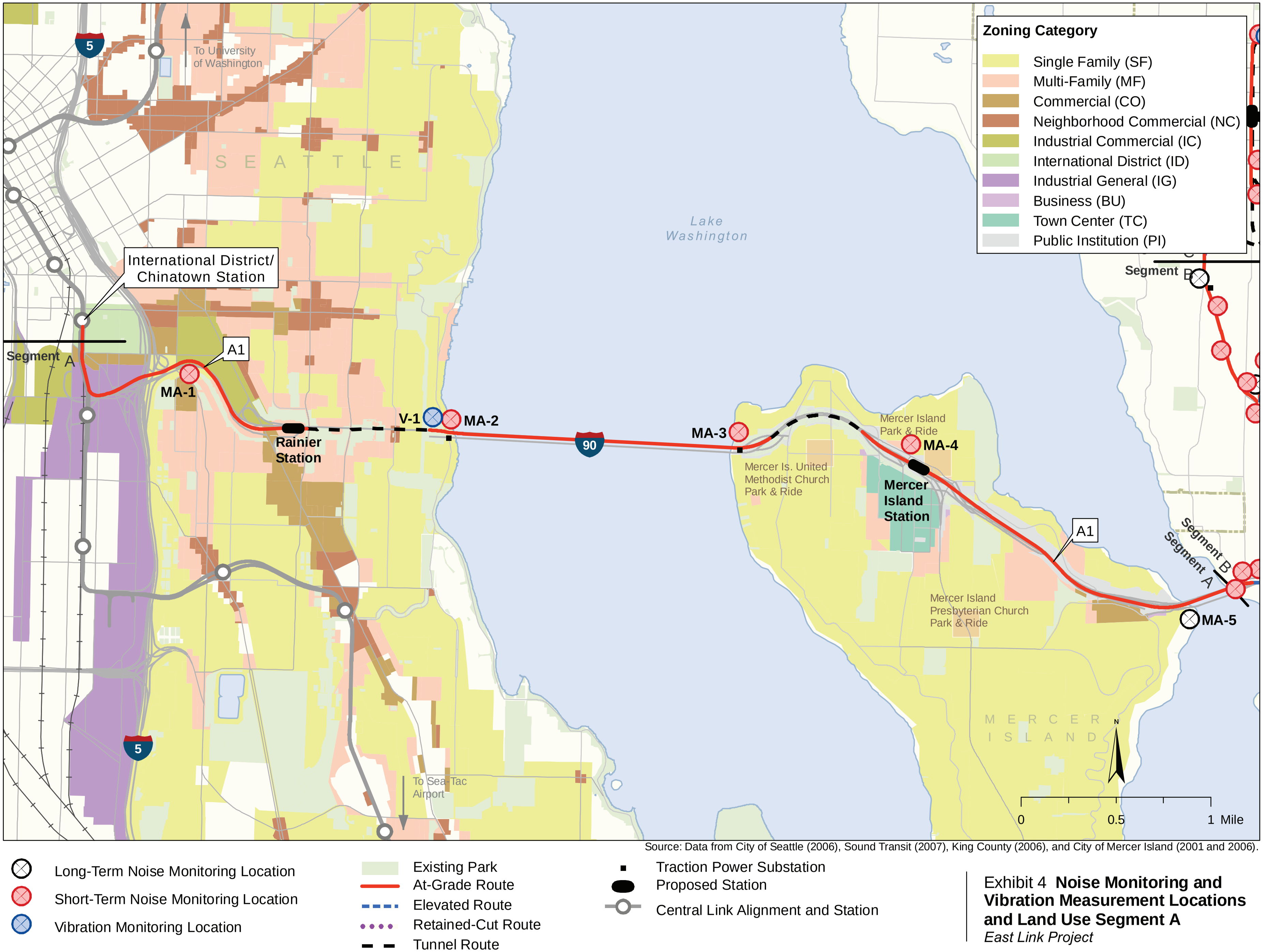
3.2.1 Segment A

Segment A had one long-term and four short-term monitoring locations. Noise levels along the proposed light rail alternative in Segment A are dominated by traffic noise from area highways, including I-5, I-90, and major arterial roadways such as Airport Way and Rainier Avenue S. The modeled Ldn near the alternative in the Seattle area was 69 dBA. Peak-hour noise levels measured at two different representative locations ranged from 67 to 68 dBA Leq.

Near the entrance to the Mercer Island Tunnel, the modeled Ldn was 65 dBA and the measured peak-hour Leq was 65 dBA. At residences near the existing Mercer Island Park-and-Ride Lot, the modeled Ldn was 54 dBA and the measured peak-hour noise level was 51 dBA Leq. The measured Ldn at the east end of Mercer Island was 55 dBA and the peak-hour Leq was 56 dBA. Table 3 provides a summary of the noise monitoring for Segment A, and Exhibit 4 shows the monitoring sites.

TABLE 3
Segment A Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MA-1	Taejon Park	Park	Short-term	68	69
MA-2	East Portal Park	Park	Short-term	68	69
MA-3	West Mercer Way Park	Park	Short-term	65	65
MA-4	2257 80th Avenue SE	Single-family	Short-term	51	54
MA-5	3700 East Mercer Way	Single-family	Long-term	56	55



Source: Data from City of Seattle (2006), Sound Transit (2007), King County (2006), and City of Mercer Island (2001 and 2006).

Exhibit 4 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment A**
East Link Project

3.2.2 Segment B

Segment B has the highest number of noise-sensitive receivers and, therefore, had the highest number of noise-monitoring locations. There were 17 monitoring locations in Segment B, including 4 long-term sites and 13 short-term sites. Measured existing Ldn ranged from 54 to 69 dBA. Overall peak-hour noise levels in south Bellevue ranged from 50 to 72 dBA Leq. The highest noise levels were measured at locations near I-90 and along Bellevue Way.

Measured peak-hour noise levels at Enatai Beach Park were 62 dBA Leq. Noise levels at this location are lower than other locations near I-90, because the site is well below the highway and is shielded somewhat from traffic noise by crash barriers. For the residential areas along SE 34th Street (MB-2 through MB-4), the Ldn was modeled to range from 66 to 72 dBA, with peak-hour noise levels from 64 to 72 dBA Leq. The main source of noise in this area is traffic on I-90.

Existing noise levels at residential land uses along the southern end of Bellevue Way (MB-6 though MB-9) ranged from 53 to 72 dBA Ldn. Site MB-7 is located uphill from Bellevue Way with some shielding from roadway noise, resulting in lower noise levels in this area. The locations with the highest measured levels are directly adjacent to Bellevue Way and have little or no shielding from the roadway. Noise levels along the northern section of Bellevue Way (MB-10 through MB-13), from 112th Avenue SE to SE 6th Street, ranged from 60 to 67 dBA Leq during peak hours, and the Ldn ranged from 62 to 69 dBA. Major noise sources in this area include Bellevue Way and I-90.

Along SE 112th Avenue, for the 112th SE At-Grade (B2A), 112th SE Elevated (B2E), and 112th SE Bypass (B3) alternatives, the Ldn ranged from 55 to 64 dBA with peak-hour levels ranging from 55 to 62 dBA Leq. For the BNSF Alternative (B7) along I-405, noise levels at the nearby multifamily units were measured at 58 to 62 dBA Leq and the Ldn levels were modeled to range from 60 to 64 dBA. The multifamily units along the BNSF rail line are somewhat shielded from I-405 traffic noise by topographical conditions. Table 4 provides a summary of the noise measurements and projections for Segment B, and Exhibit 5 shows the monitoring sites.

TABLE 4
Segment B Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MB-1	Enatai Beach Park	Park	Short-term	62	62
MB-2	3457 107th Avenue SE	Single-family	Short-term	64	66
MB-3	3246 109th Avenue SE	Single-family	Short-term	72	72
MB-4	3264 111th Avenue SE	Single-family	Long-term	64	66
MB-5	3218 113th Avenue SE	Single-family	Short-term	70	72
MB-6	3005 113th Avenue SE	Single-family	Short-term	67	69
MB-7	11035 SE 26th Street	Single-family	Long-term	50	53
MB-8	11038 SE 25th Street	Single-family	Short-term	61	63
MB-9	1928 109th Avenue SE	Single-family	Short-term	64	66
MB-10	1850 108th Avenue SE	Single-family	Short-term	63	65
MB-11	1435 Bellevue Way	Single-family	Short-term	64	66
MB-12	1030 Bellevue Way	Multifamily	Short-term	67	69
MB-13	10256 SE 8th Street	Multifamily	Long-term	60	62

TABLE 4
Segment B Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MB-14	1638 SE 17th Street	Single-family	Long-term	58	60
MB-15	1600 109th Avenue SE	Single-family	Short-term	55	55
MB-16	1018 111th Avenue SE	Single-family	Short-term	62	64
MB-17	2500 118th Avenue SE, Unit 303	Multi-family	Short-term	62	64

3.2.3 Segment C

There were 14 noise-monitoring locations in downtown Bellevue, including 4 long-term sites and 10 short-term sites. Peak-hour noise levels ranged from 57 dBA Leq in quiet areas away from major arterial roads to 75 dBA Leq near the Hilton Hotel along I-405 (MC-3). The modeled Ldn at the Hilton Hotel was 75 dBA. Noise levels at residences along Bellevue Way ranged from 66 dBA Ldn for properties near the roadway to 60 dBA Ldn for properties shielded from roadway noise.

The measured noise level at the Bellevue Regional Library (MC-10) was 62 dBA Leq. Noise levels at single-family residences along NE 12th Street ranged from 59 dBA Ldn for shielded properties to 68 dBA Ldn for residences adjacent to major arterial roads. Noise levels in Downtown Bellevue ranged from 57 to 64 dBA Leq, depending on the location, level of local traffic, and proximity to major arterial roads. Major noise sources included traffic on main arterial roads, including 112th Avenue, Bellevue Way, NE 12th Street, NE 8th Street, Main Street, and I-90. Table 5 provides a summary of the noise measurements and modeled 24-Hour Ldn for Segment C, and Exhibit 6 shows the monitoring sites.

TABLE 5
Segment C Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MC-1	420 Bellevue Way SE	Multifamily	Short-term	66	66
MC-2	321 Bellevue Way SE	Multifamily	Long-term	60	60
MC-3	300 112th Avenue SE	Hotel	Short-term	75	75
MC-4	221 112th Avenue SE, #221	Multi-family	Short-term	69	71
MC-5	11039 SE 2nd Street	Single-family	Short-term	57	58
MC-6	80 110th Avenue NE	Single-family	Long-term	57	59
MC-7	100 108th Ave SE	Office	Short-term	61	63
MC-8	225 112th Avenue SE	Commercial	Short-term	62	63
MC-9	308 108th Avenue NE	Commercial	Short-term	64	65
MC-10	Bellevue Regional Library, 1111 110th Avenue NE	Mixed-use	Short-term	62	63
MC-11	10814 NE 12th Place	Single-family	Short-term	58	59
MC-12	11121 NE 12th Street	Commercial	Short-term	67	68

TABLE 5
Segment C Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MC-13	1245 112th Avenue NE	Office	Long-term	57	60
MC-14	Surrey Downs Park	Park	Long-term	62	64

3.2.4 Segment D

Because much of Segment D is commercial and light industrial uses, which are not typically sensitive to light rail noise, only five sites were monitored, with only one long-term monitoring site at a residential area along 116th Avenue NE. Noise levels for these residences were dominated by traffic on I-405 and 116th Avenue NE. An Ldn of 58 dBA was measured along the side of 116th Avenue NE facing the SR 520 Alternative (D5), which is well shielded from I-405. There was also a monitoring location near the Highland Park and Community Center, where the peak-hour level was measured at 65 dBA Leq. The main noise sources included SR 520, Bel-Red Road, and NE 20th Street.

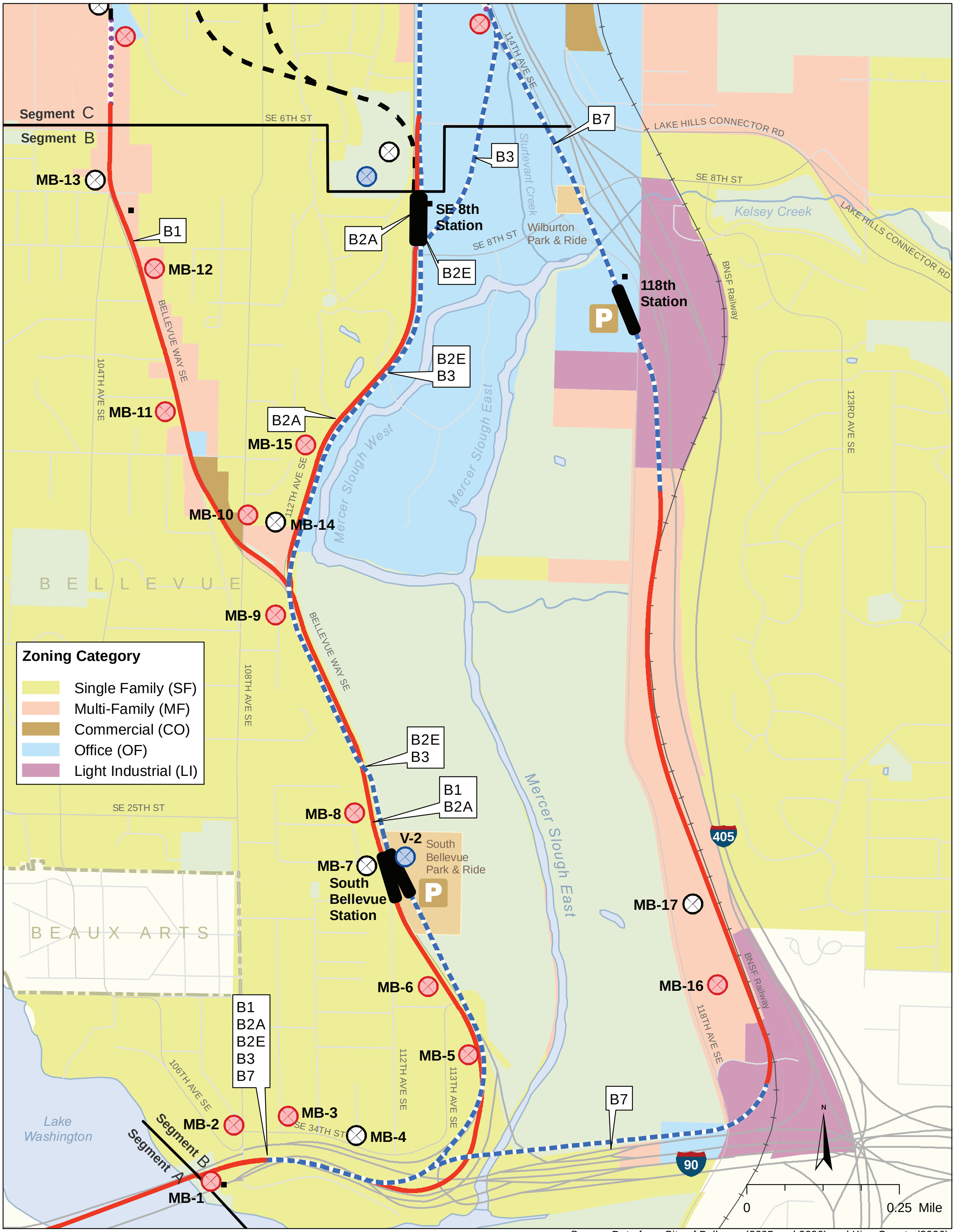
Three additional noise measurement sites were located near the Overlake area, including one near the former Group Health Eastside Hospital, one at the Overlake Assisted Living Center, and one on the Microsoft Campus near Building 44. Estimated noise levels at these sites ranged from 65 to 71 dBA Ldn, with measured peak hour Leq levels ranging from 64 to 70 dBA Leq. Table 6 provides a summary of the noise measurements and modeled 24-Hour Ldn for Segment D, and Exhibit 7 shows the monitoring sites.

TABLE 6
Segment D Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
MD-1	1815 116th Avenue	Single-family	Long-term	58	58
MD-2	Near Highland Park (On pathway 50 feet from NE 20th Street)	Park	Short-term	65	65
MD-3	Former Group Health Campus, 2700 152nd Avenue NE (to be redeveloped as mixed use)	Commercial	Short-term	64	65
MD-4	Overlake Assisted Living Center, 2956 152nd Avenue NE	Commercial	Short-term	64	65
MD-5	Near Microsoft Building 44	Mixed-use	Short-term	70	71

3.2.5 Segment E

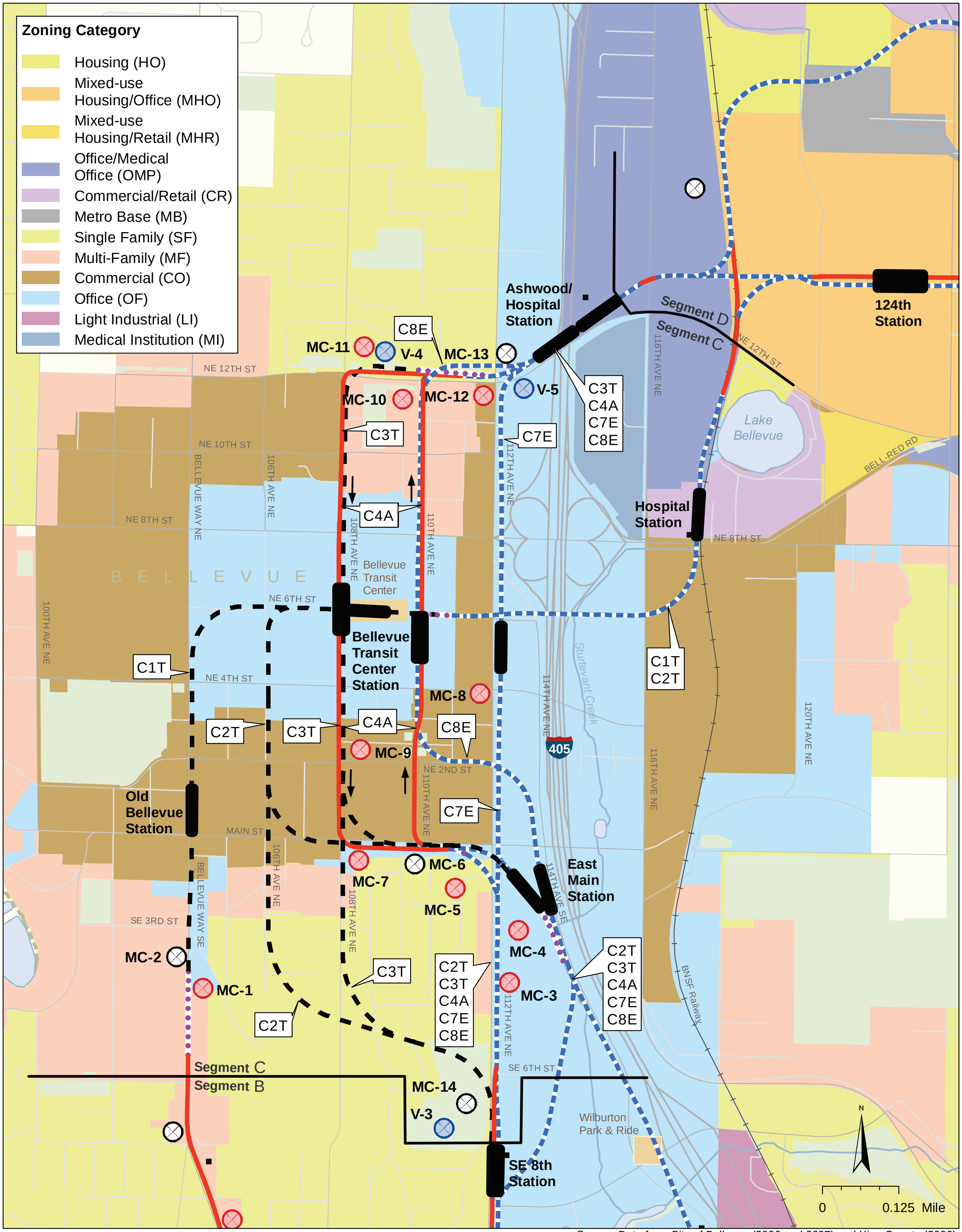
There were five noise-monitoring locations in Segment E, including two long-term sites and three short-term sites The initial portion of all light rail alternatives in Segment E is along the east side of SR 520, shielded from nearby residences by existing sound walls. For locations with existing noise walls, Ldn ranged from 60 to 64 dBA with peak-hour levels of 58 to 60 dBA Leq. There is a small group of homes along 156th Avenue NE that does not have a noise wall (ME-2), and the measured Ldn was 68 dBA at this location.



Source: Data from City of Bellevue (2005 and 2006) and King County (2006).

Long-Term Noise Monitoring Location
Short-Term Noise Monitoring Location
Vibration Monitoring Location
Existing Park
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Traction Power Substation
Proposed Station
New and/or Expanded Park-and-Ride Lot

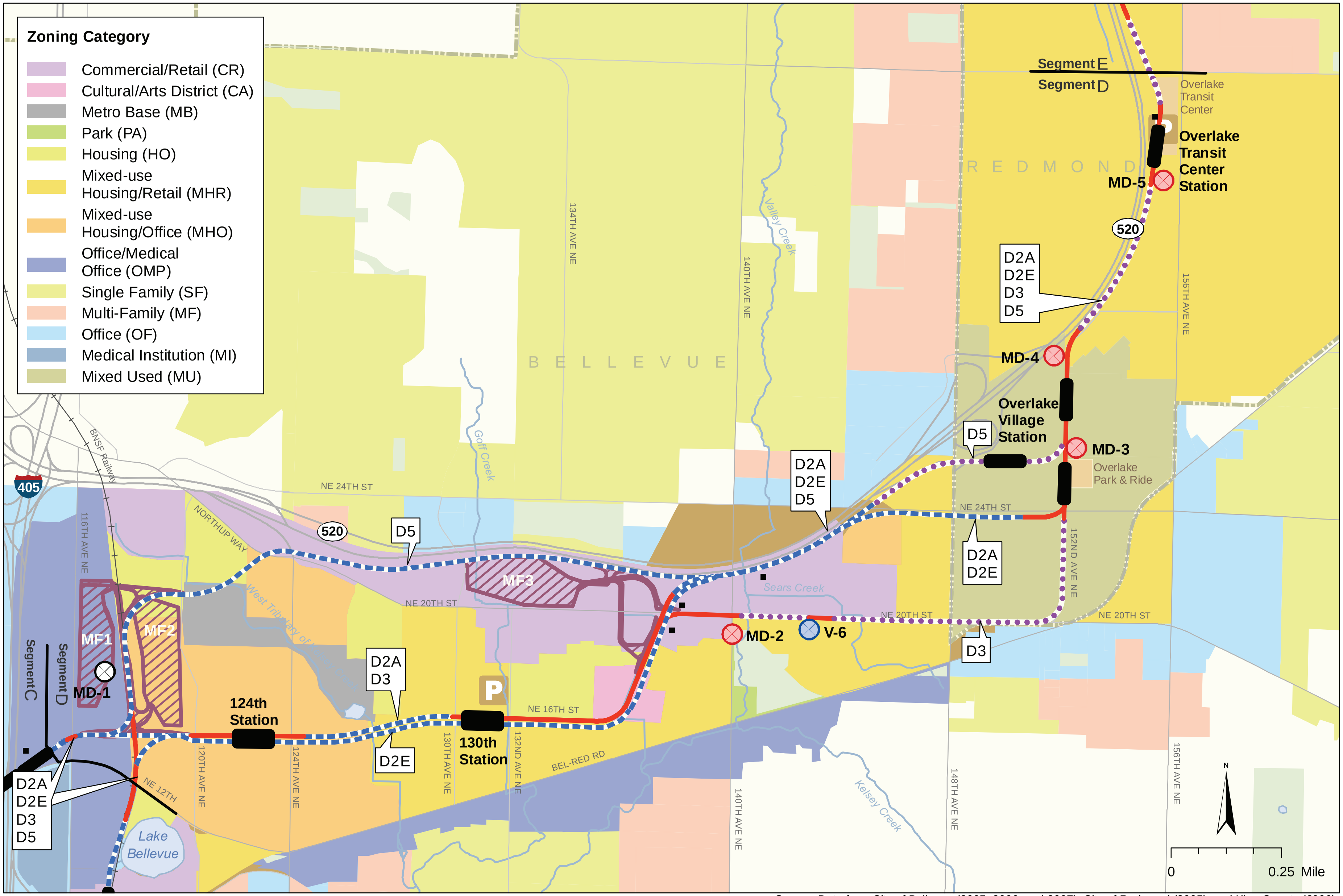
Exhibit 5 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment B**
East Link Project



Source: Data from City of Bellevue (2006 and 2007) and King County (2006).

Long-Term Noise Monitoring Location
Short-Term Noise Monitoring Location
Vibration Monitoring Location
Existing Park
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Traction Power Substation
Proposed Station
New and/or Expanded Park-and-Ride Lot

Exhibit 6 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment C**
East Link Project

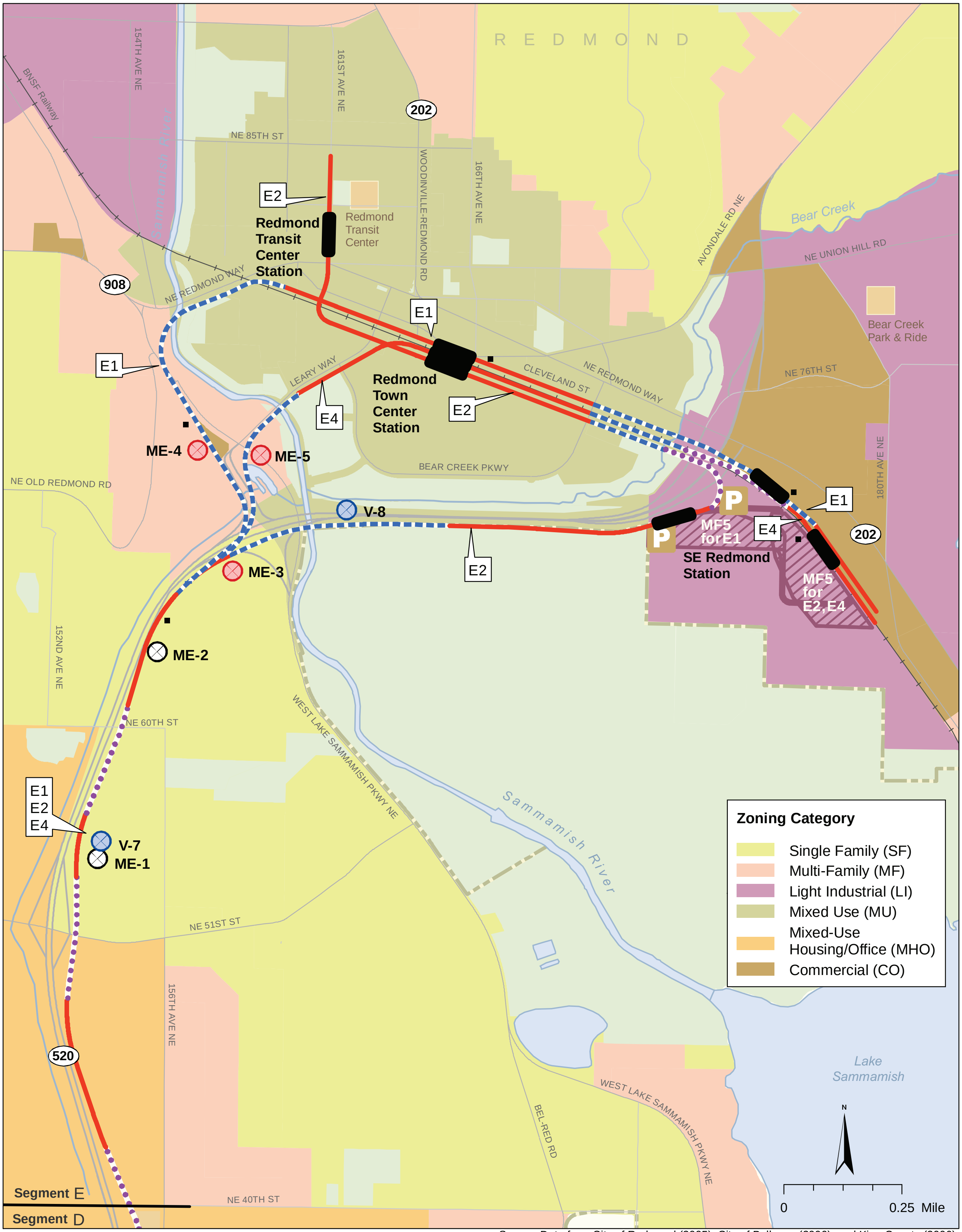


Source: Data from City of Bellevue (2005, 2006, and 2007), City of Redmond (2005), and King County (2006).

- Long-Term Noise Monitoring Location
- Short-Term Noise Monitoring Location
- Vibration Monitoring Location
- Existing Park
- At-Grade Route
- Elevated Route
- Retained-Cut Route
- Tunnel Route
- Traction Power Substation
- Proposed Station
- Maintenance Facility and Access Track
- New and/or Expanded Park-and-Ride Lot

NOTE: Zoning has not been adopted and is still under review.

Exhibit 7 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment D**
East Link Project



Source: Data from City of Redmond (2005), City of Bellevue (2006), and King County (2006).

Exhibit 8 **Noise Monitoring and Vibration Measurement Locations and Land Use Segment E**
East Link Project

Noise at the multifamily units along 156th Place NE (ME-4) were also dominated by traffic on SR 520 and arterial roads, with an estimated Ldn of 64 dBA. The apartments along NE Leary Way and West Lake Sammamish Parkway (ME-5) had an estimated Ldn of 64 dBA, with most noise coming from the two main arterial roadways. Table 7 provides a summary of the noise measurements and modeled 24-hour Ldn for Segment E, and Exhibit 8 shows the monitoring sites.

TABLE 7
Segment E Noise Measurements and Modeled 24-Hour Ldn

Monitoring Location #[a]	Address	Land Use Type	Type of Measurement	Leq (Peak-hour Leq in dBA)	Ldn (24-hour Ldn in dBA)
ME-1	5409 154th Avenue NE	Single-family	Long-term	60	64
ME-2	15516 61st Court	Single-family	Long-term	65	68
ME-3	15834 NE 67th Place	Single-family	Short-term	58	60
ME-4	7250 Old Redmond Road	Multifamily	Short-term	63	64
ME-5	15821 Leary Way NE	Multifamily	Short-term	62	64

[a] Sites shown on Exhibit 8

3.2.6 Maintenance Facilities

The maintenance facilities are proposed in areas that are currently light industrial land uses and have no nearby noise-sensitive land uses. The exception is the 116th Maintenance Facility (MF1), where some residences are located to the west side between 116th Avenue NE and I-405, and the proposed Children's Hospital will be located to the south. One site in this area was monitored and is discussed in Section 3.2.4, Segment D.

3.3 Vibration Measurements

3.3.1 Locations and Tests

Vibration measurement test sites were selected based on a review of aerial photographs and were supplemented by a visual land-use survey. Unlike noise, human response to vibration is not dependent on existing vibration levels. Humans respond to a new source of vibration based on the frequency of the events. Therefore, rather than measuring existing vibration levels, the vibration measurements for the project focused on characterizing the vibration propagation through the ground at representative locations. Eight sites, designated as V-1 through V-8, were selected to represent a range of soil conditions in areas along the rail corridor near sensitive land uses. Measurements were conducted at selected sites in Seattle, Bellevue, and Redmond. The locations of these measurement sites are indicated previously in Exhibits 4 through 8 along with the noise monitoring locations- and are described below. Site photographs are included in Appendix B of this report.

Site V-1: This site was located at the corner of 32nd Avenue and South Day Street in Seattle, above the I-90 tunnel. The vibration measurements at this site are representative of Segment A.

Site V-2: This site was located in the parking lot of the South Bellevue Park-and-Ride Lot. The vibration measurements at this site are taken representative of the southern portions of Segment B.

Site V-3: This site was located in the parking lot of the King County District Court in Surrey Downs Park. The vibration measurements at this site are representative of the northern portion of Segment B and the at-grade and elevated alternatives in Segment C, except for Overlake Hospital.

Site V-4a and V-4b: This site was located in the median of NE 12th Street, between 108th Avenue NE and 110th Avenue NE. The vibration measurements at this site are representative of the tunnel alternatives in Segment C.

Site V-5: This site was located in the parking lot of Overlake Hospital, adjacent to NE 12th Street. The vibration measurements at this site are representative of Overlake Hospital and were used in the assessment of impact for the vibration sensitive equipment, including the mobile MRI and the optical surgery unit within this facility.

Site V-6: This site was located in Highland Park off Bel-Red Road in Bellevue. The vibration measurements at this site are representative of Segment D.

Site V-7: This site was located at the corner of 154th Avenue NE and NE 54th Street in Redmond, in a residential neighborhood. The vibration measurements at this site are representative of the southern portion of Segment E, along SR 520.

Site V-8: This site was located at the Redmond Town Center, along Bear Creek Trail to the south of the commercial buildings. The vibration measurements at this site are representative of the areas along the northern portion of Segment E, near the Redmond Town Center.

3.3.2 Instrumentation and Procedures

Vibration propagation is characterized by the relationship between an input force and the resulting ground-surface vibration, called the transfer mobility. Transfer mobility measurements are made by producing an impulsive force and measuring the vibration response at accelerometers located at a range of distances. With the transfer mobility, it is possible to estimate the ground vibration that would be caused by sources, such as a train, by substituting the impact force with the train forces.

The vibration propagation test system for surface alternatives is shown schematically in Exhibit 9, and Exhibit 10 shows the test system for tunnel alternatives. As shown in the cross-section view at the top of Exhibit 9, the surface test consists of dropping a 60-pound weight from a height of 3 to 4 feet onto the ground to generate a force. For tunnel testing, a drill rig is used to generate the force at the required tunnel depth.

The measurement equipment includes a load cell to measure the forces produced by the weight, high-sensitivity accelerometers, amplifiers, and an eight-channel digital audio tape (DAT) recorder. The accelerometers are located on either paved surfaces or on top of steel stakes driven into soil and mounted with a clay compound in the vertical orientation. During the measurements, personnel continually monitor the recording levels and listen to the acceleration signals to make sure that acceptable data are collected.

The sketch in the lower half of Exhibit 9 shows how the dropped weight point source was used to simulate a line vibration source such as a train. Impact tests were made at regular intervals in a line along the rail alternative. For these tests, impacts were done at 11 points spaced 15 feet apart. Six accelerometers were placed perpendicular to the impact locations at distances between 25 and 150 feet away. For each impact location, approximately 25 impacts were produced in order to obtain a statistically accurate sample.

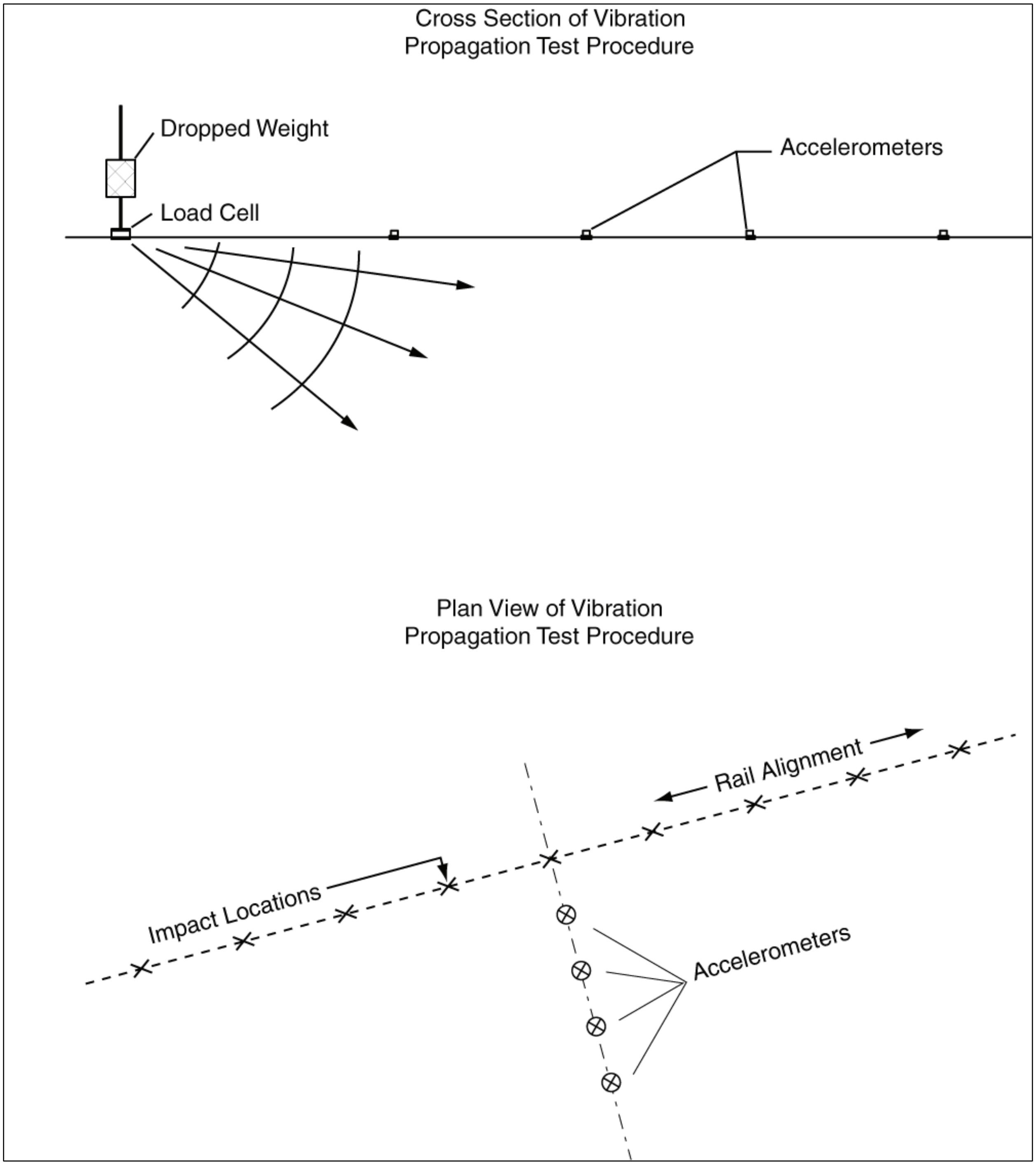


EXHIBIT 9
Surface Vibration Propagation Test Procedure

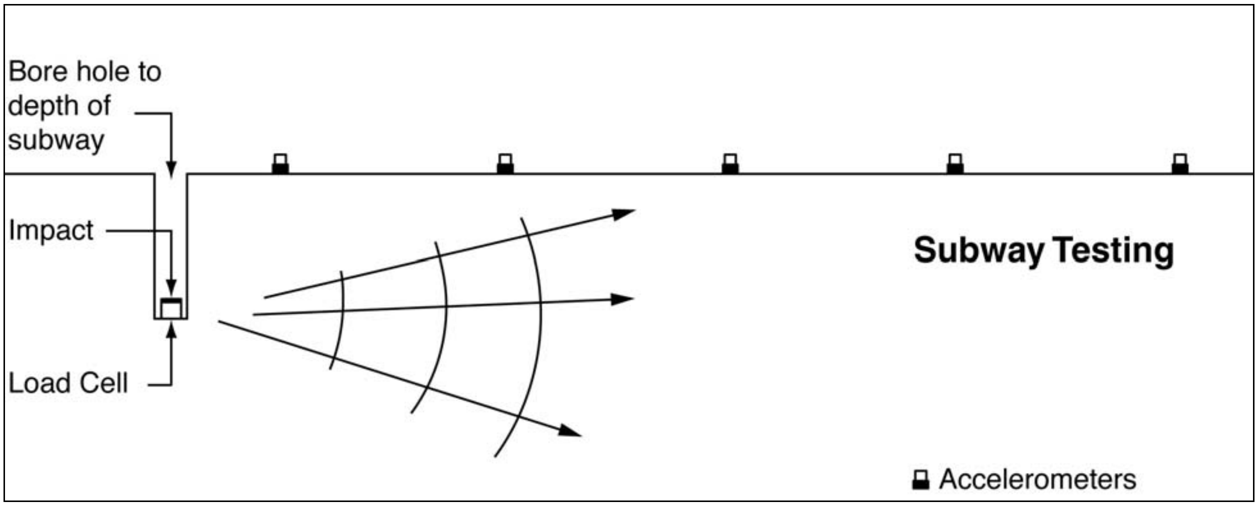


EXHIBIT 10
Vibration Propagation Test Procedure for Tunnels

3.4 Vibration Propagation Results

Data recorded in the field were then analyzed in the laboratory using digital signal processing software that calculates the point-source transfer mobility and coherence between each impact and accelerometer location. Coherence is a measure of how accurate the transfer mobility is calculated. The basic steps of the analysis include the following:

- Each impulse signal from the load cell and response signals from the accelerometers was identified in the recordings.
- Narrowband transfer functions and coherences were computed from an average of all the impulses at a specific impact location.
- The narrowband transfer functions and coherences were summed into 1/3-octave band levels.
- A linear or quadratic regression was calculated for all of the point-source transfer mobilities in each 1/3-octave band. These transfer mobility regressions were used to compute smooth point-source transfer mobility versus distance relationship.
- Each of the 1/3-octave band point-source transfer mobility relationships were then integrated into an equivalent line-source transfer mobility using Simpson's rule for numerical integration. The end result was an estimate of line source transfer mobility based on the distance from the source of the vibration.

Examples of the resulting smoothed line source transfer mobilities are provided in Exhibits 11 through 13, which provide the spectra at a distance of 100 feet for each test site. More details on the propagation test and analysis procedures are given the FTA guidance manual *Transit Noise and Vibration Impact Assessment*. Detailed vibration propagation data for the project are included in Appendix C of this report.

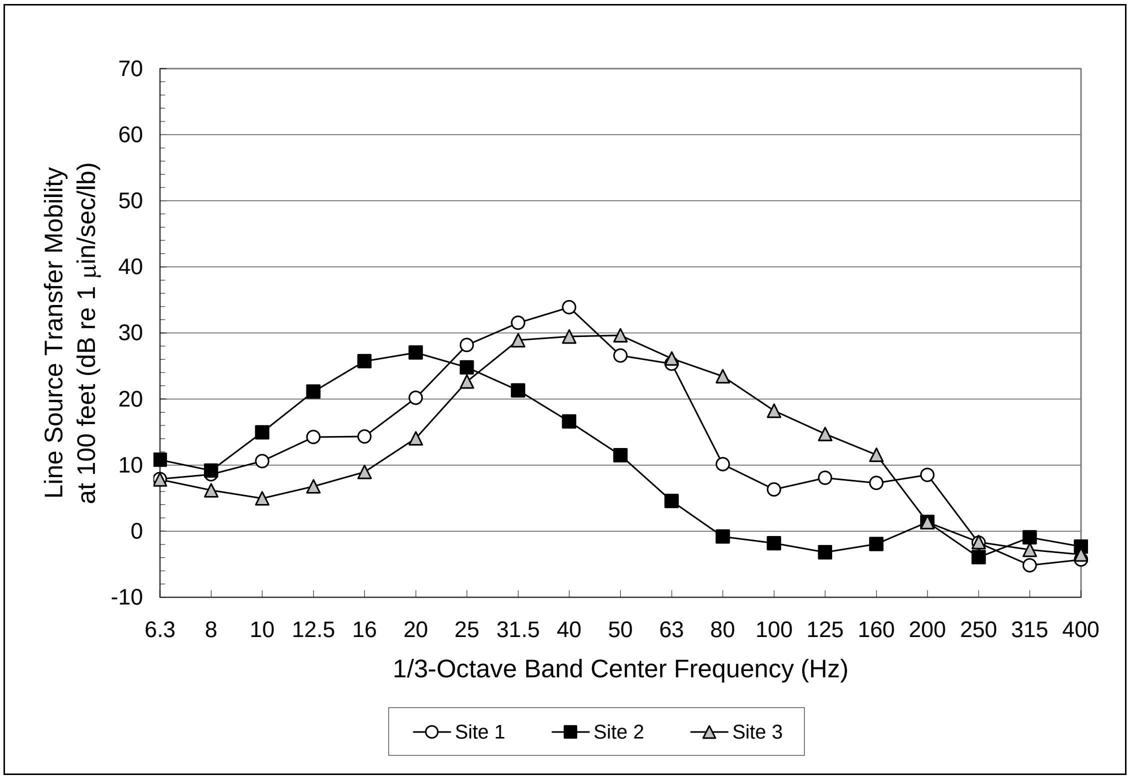


EXHIBIT 11
Line Source Transfer Mobilities for Sites V-1 to V-3

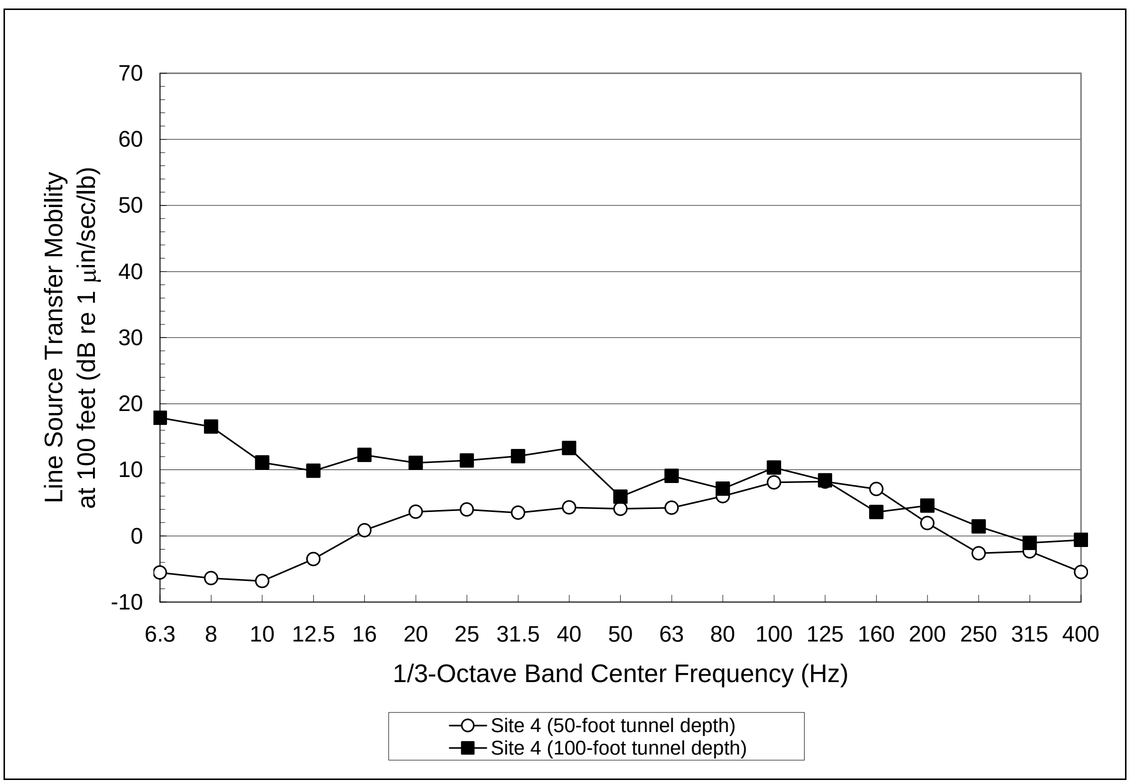


EXHIBIT 12
Line Source Transfer Mobilities for Site V-4

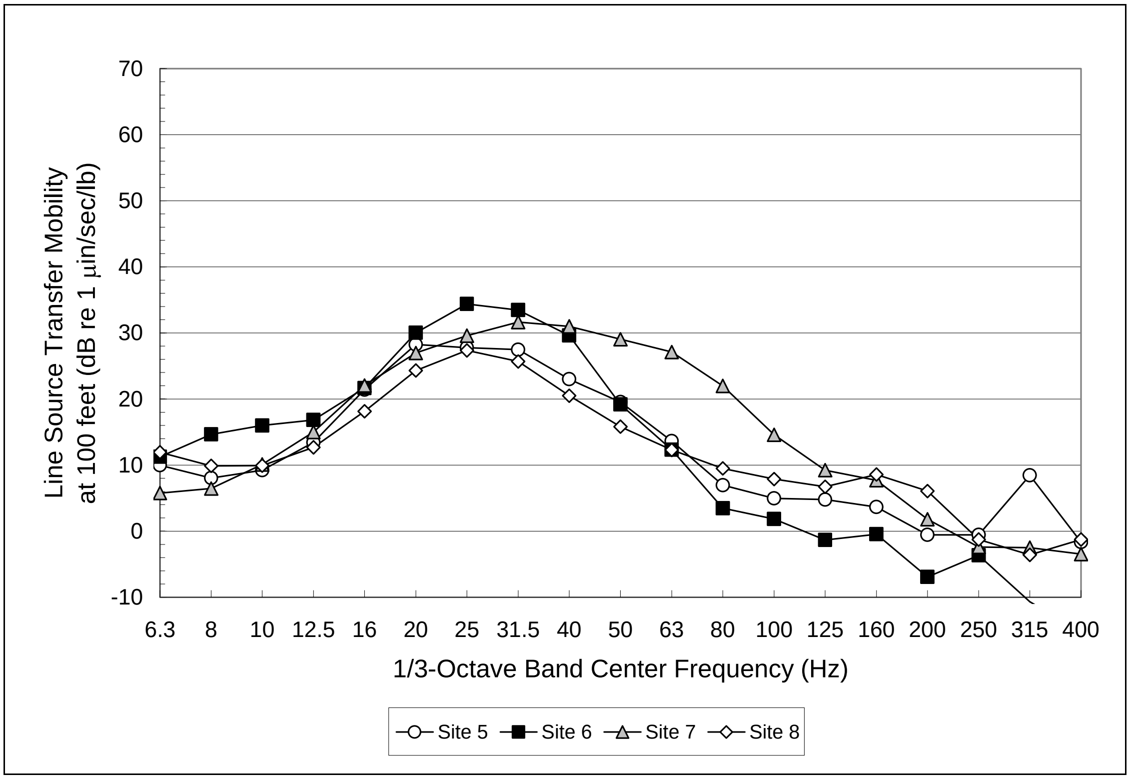


EXHIBIT 13
Line Source Transfer Mobilities for Sites V-5 to V-8

4.0 Noise and Vibration Impact Criteria

The operation of a light rail system can cause noise and vibration that can be a major public concern. Noise impacts can be caused by either transit operations or changes in traffic resulting from a roadway being widened or realigned for the project, and different criteria exist for each source of noise. In addition, ground-borne noise caused by vibration has different impact criteria. This section summarizes what defines a noise and vibration impact, as applicable to the East Link Project.

4.1 Transit Noise Criteria

Noise impacts for this project are determined based on the criteria defined in the FTA guidance manual *Transit Noise and Vibration Impact Assessment* (FTA, 2006). The FTA noise impact criteria are based on well-documented research on community reaction to noise and on change in noise exposure rated using a sliding scale. Although more transit noise is allowed in neighborhoods with high levels of existing noise, as existing noise levels increase, smaller increases in total noise exposure are allowed than in areas with lower existing noise levels. The FTA Noise Impact Criteria group noise-sensitive land uses into the following three categories:

- **Category 1**: Buildings or parks where quiet is an essential element of their purpose.
- **Category 2**: Residences and buildings where people normally sleep. This includes residences, hospitals, and hotels where nighttime sensitivity is assumed to be of utmost importance.
- **Category 3**: Institutional land uses with primarily daytime and evening use. This category includes schools, libraries, churches, and active parks.

Ldn is used to characterize noise exposure for residential areas (Category 2). For other noise-sensitive land uses, such as outdoor amphitheaters and school buildings (Categories 1 and 3), the maximum 1-hour Leq during the facility's operating period is used.

There are two levels of impact included in the FTA criteria, severe and moderate, interpreted as follows:

- **Severe Impact:** Project-generated noise in the severe impact range can be expected to cause a large percentage of people to be highly annoyed by the new noise and represents the most compelling need for mitigation. Noise mitigation will normally be specified for severe impact areas unless there are truly extenuating circumstances that prevent it.
- **Moderate Impact:** In this range of noise impact, the change in the cumulative noise level is noticeable to most people but may not be sufficient to cause strong, adverse reactions from the community. In this transitional area, other project-specific factors must be considered to determine the magnitude of the impact and the need for mitigation. These factors include the existing level, the predicted level of increase over existing noise levels, the types and numbers of noise-sensitive land uses affected, the noise sensitivity of the properties, the effectiveness of the mitigation measures, community views, and the cost of mitigating noise to more acceptable levels.

The FTA noise impact criteria are summarized in graphical form in Exhibit 14, which shows the existing noise exposure and the additional noise exposure from the transit project that would cause either moderate or severe impact. The future noise exposure would be the combination of the existing noise exposure and the additional noise exposure caused by the transit project. Exhibit 15 expresses the same

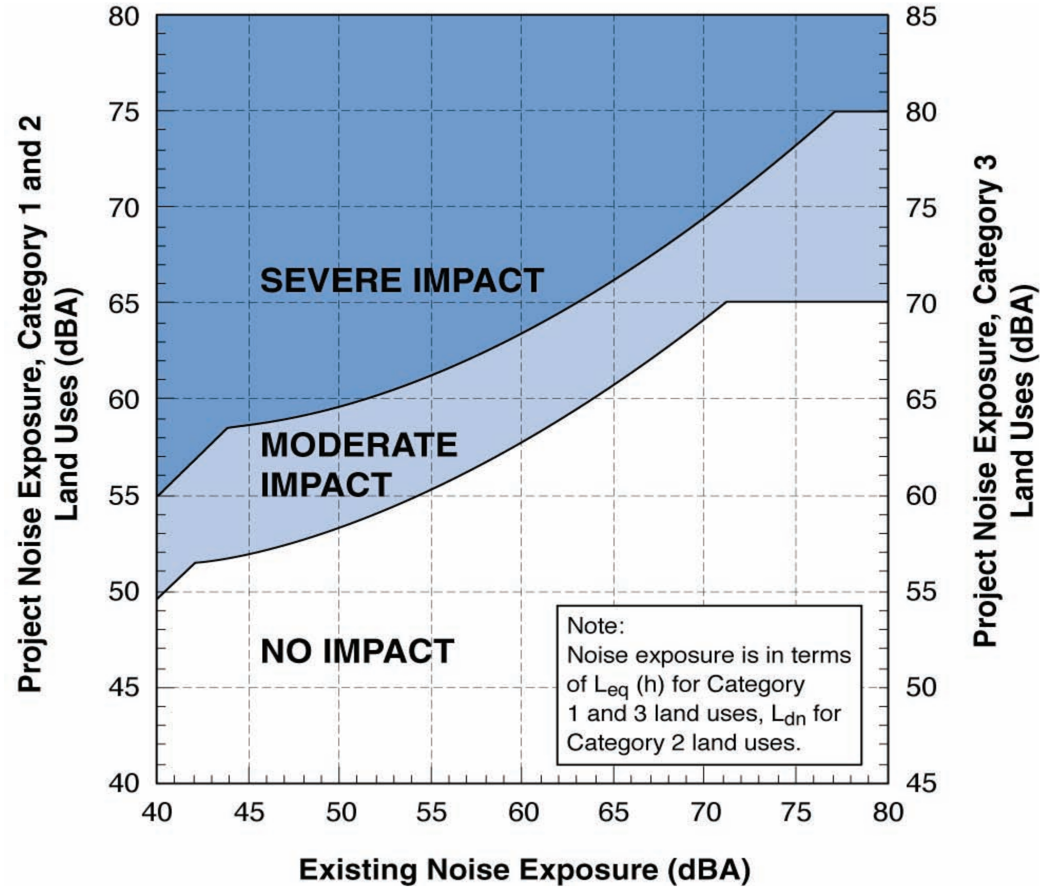


EXHIBIT 14
FTA Project Noise Impact Criteria
Note: Leq(h) = hourly Leq

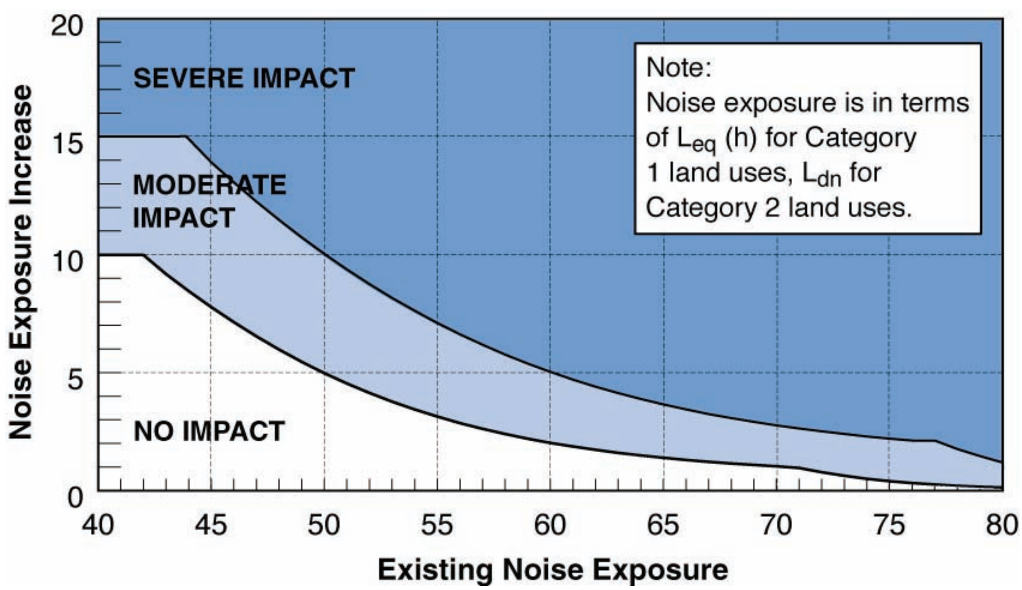


EXHIBIT 15
Increase in Cumulative Noise Exposure Allowed by FTA Criteria

Note: Leq(h) = hourly Leq

criteria in terms of the increase in total or cumulative noise that can occur in the overall noise environment before an impact occurs.

4.2 Traffic Noise Criteria

Consistent with the FTA manual, FHWA methodology and criteria are used to evaluate traffic noise impacts. The criteria for highway noise impacts are taken from the FHWA Procedures for Abatement of Highway Traffic Noise and Construction Noise, United States Code of Federal Regulations (CFR) 23 772, 1982. The traffic noise abatement criteria are listed in Table 8. A noise impact occurs if predicted noise levels approach the levels listed in Table 8 or substantially exceed existing noise levels. Each state defines their own quantitative levels considered to approach or substantially exceed existing noise levels. Projects that include construction of new highways, reconstruction of existing highways that includes significantly changing either the horizontal or vertical profile, or an increase in the number of through traffic lanes require analysis and consideration of abatement. A significant change in the horizontal or vertical profile occurs when the change is likely to result in increased noise levels to developed lands.

TABLE 8
FHWA Traffic Noise Abatement Criteria

Land Use Category		Hourly Leq (dBA)
Type A	Lands on which serenity and quiet are of extraordinary significance and which serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose	57 (exterior)
Type B	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals	67 (exterior)
Type C	Developed lands, properties, or activities not included in the above categories	72 (exterior)
Type D	Undeveloped land	—
Type E	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums	52 (interior)

The Washington State Department of Transportation (WSDOT) is responsible for implementing the FHWA regulations in Washington. Under WSDOT policy, a traffic noise impact occurs if predicted noise levels are within 1 dB of the FHWA criteria; therefore, a residential impact occurs at 66 dBA Leq and a commercial impact occurs at 71 dBA Leq. WSDOT also considers a 10-dB increase in noise a substantial increase impact, regardless of the existing noise level.

Potential noise from park-and-ride lots were assessed using the local noise criteria which is discussed later in Section 4.4.1 for construction noise.

4.3 Transit Vibration and Ground-Borne Noise Criteria

The FTA ground-borne vibration impact criteria are based on land use and train frequency. The criteria for most land uses are shown in Table 9. There are some buildings, such as concert halls, recording studios, and theaters, that can be particularly sensitive to vibration but do not fit into any of the three categories listed in Table 9. Due to their sensitivity, these buildings usually warrant special attention during the impact assessment. Table 10 gives criteria for acceptable levels of ground-borne vibration for various types of special buildings.

Table 11 provides vibration criteria for detailed vibration analyses at highly sensitive locations . The criteria in Table 11 are based on exceedences of the 1/3-octave-band vibration levels over the frequency range 8 to 80 Hz. In addition, these detailed criteria would be used to assess vibration impact at highly sensitive locations, such as the Overlake Hospital, the Group Health and the proposed Children's

Hospital because of potentially sensitive medical equipment and procedures. These criteria are also shown graphically in Exhibit 16.

It should also be noted that Tables 9 and 10 include separate FTA criteria for ground-borne noise, the "rumble" that can be radiated from the motion of room surfaces in buildings due to ground-borne vibration. The vibration of floors and walls causes them to act like loudspeakers, generating noise due to the movement of the surfaces. Although expressed in dBA, which emphasizes the more audible middle and high frequencies, the criteria are set considerably lower than for airborne noise to account for the annoying low-frequency character of ground-borne noise. Because airborne noise often masks ground-borne noise for aboveground (i.e., at-grade or elevated) transit systems, ground-borne noise criteria are primarily applied to subway operations where airborne noise is not a factor. For above-grade transit systems, ground-borne noise criteria are applied only to buildings that have sensitive interior spaces that are well insulated from exterior noise.

TABLE 9
Ground-Borne Vibration and Noise Impact Criteria

Land Use Category	Ground-Borne Vibration Impact Levels (VdB re 1 micro inch/second)			Ground-Borne Noise Impact Levels (dB re 20 micro Pascals)		
	Frequent Events[a]	**Occasional Events**[b]	**Infrequent Events**[c]	**Frequent Events**[a]	**Occasional Events**[b]	**Infrequent Events**[c]
Category 1: Buildings where low ambient vibration is essential for interior operations	65 VdB[d]	65 VdB[d]	65 VdB[d]	N/A[e]	N/A[e]	N/A[e]
Category 2: Residences and buildings where people normally sleep	72 VdB	75 VdB	80 VdB	35 dBA	38 dBA	43 dBA
Category 3: Institutional land uses with primarily daytime use	75 VdB	78 VdB	83 VdB	40 dBA	43 dBA	48 dBA

[a] "Frequent Events" is defined as more than 70 vibration events of the same source per day. Most rapid transit projects fall into this category.

[b] "Occasional Events" is defined as between 30 and 70 vibration events of the same source per day. Most commuter trunk lines have this many operations.

[c] "Infrequent Events" is defined as fewer than 30 vibration events of the same kind per day. This category includes most commuter rail branch lines.

[d] This criterion limit is based on levels that are acceptable for most moderately sensitive equipment, such as optical microscopes. Vibration-sensitive manufacturing or research requires detailed evaluation to define the acceptable vibration levels. Ensuring lower vibration levels in a building often requires special design of the heating, ventilation, and air conditioning (HVAC) systems and stiffened floors.

[e] Not applicable. Vibration-sensitive equipment is generally not sensitive to ground-borne noise.

TABLE 10
Ground-Borne Vibration and Noise Impact Criteria for Special Buildings

Type of Building or Room[c]	Ground-Borne Vibration Impact Levels (VdB re 1 micro-inch/sec)		Ground-Borne Noise Impact Levels (dB re 20 micro Pascals)	
	Frequent Events[a]	Occasional or Infrequent Events[b]	Frequent Events[a]	Occasional or Infrequent Events[b]
Concert Halls	65 VdB	65 VdB	25 dBA	25 dBA
TV Studios	65 VdB	65 VdB	25 dBA	25 dBA
Recording Studios	65 VdB	65 VdB	25 dBA	25 dBA
Auditoriums	72 VdB	80 VdB	30 dBA	38 dBA
Theaters	72 VdB	80 VdB	35 dBA	43 dBA

[a] "Frequent Events" is defined as more than 70 vibration events per day. Most transit projects fall into this category.

[b] "Occasional or Infrequent Events" is defined as fewer than 70 vibration events per day. This category includes most commuter rail systems.

[c] If the building will rarely be occupied when trains are operating, there is no need to consider impact. As an example, consider locating a commuter rail line next to a concert hall: if no commuter trains will operate after 7 p.m., it should be rare that the trains would interfere with the use of the hall.

TABLE 11
Vibration Criteria for Detailed Analysis at Highly Sensitive Locations

Criterion Curve	Max Lv (VdB)[a]	Description of Use
Workshop	90	Distinctly detectable vibration. Appropriate to workshops and non-sensitive areas.
Office	84	Detectable vibration. Appropriate to offices and non-sensitive areas.
Residential Day	78	Barely detectable vibration. Adequate for computer equipment and low-power optical microscopes (up to 20X).
Residential Night, Operating Rooms/ Sensitive hospital equipment	72	Vibration not detectable, but ground-borne noise may be audible inside quiet rooms. Suitable for medium-power optical microscopes (100X) and other equipment of low sensitivity.
VC-A	66	Adequate for medium- to high-power optical microscopes (400X), microbalances, optical balances, and similar specialized equipment.
VC-B	60	Adequate for high-power optical microscopes (1000X), inspection and lithography equipment to 3 micron line widths.
VC-C	54	Appropriate for most lithography and inspection equipment to 1 micron detail size.
VC-D	48	Suitable in most instances for the most demanding equipment, including electron microscopes operating to the limits of their capability.
VC-E	42	The most demanding criterion for extremely vibration-sensitive equipment.

[a] As measured in 1/3-octave bands of frequency over the frequency range 8 to 80 Hz.

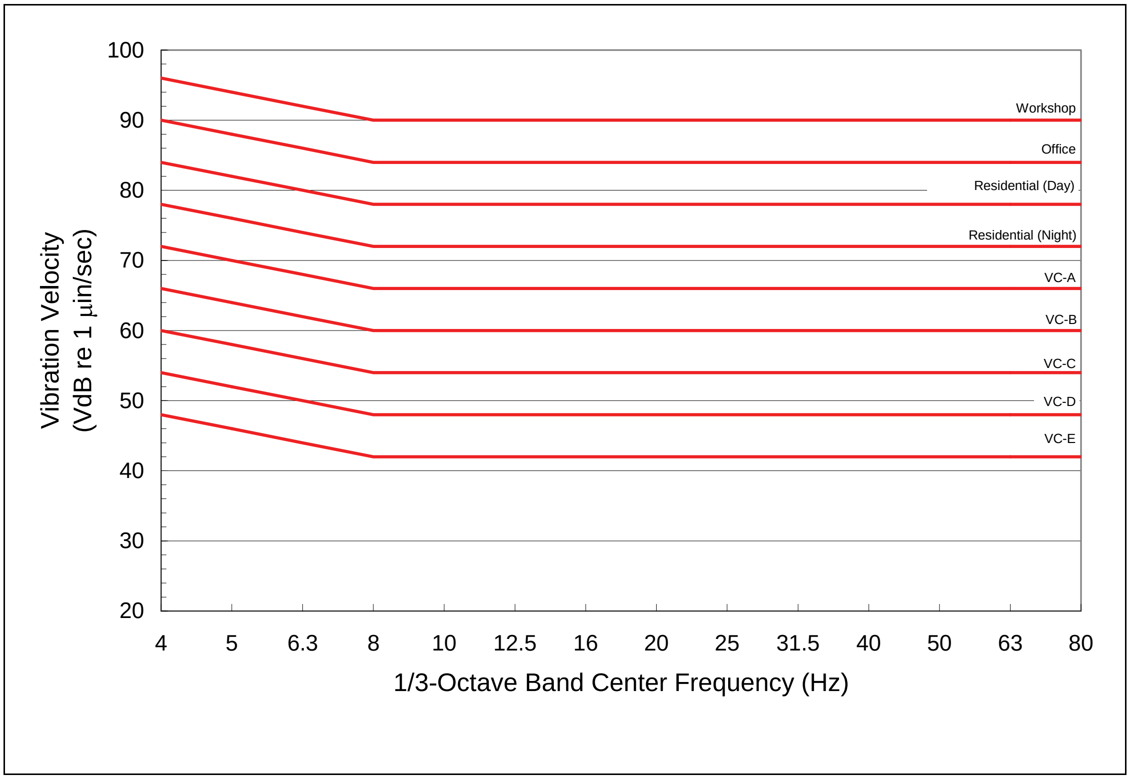


EXHIBIT 16
Vibration Criteria for Highly Sensitive Locations

4.4 Construction Noise Criteria

Project construction will take place in four cities within King County, so several different noise ordinances may be applicable to project construction. Most cities in Washington, including all those in the project corridor, rely on the Washington State Administrative Code (WAC), Chapter 173-60, Maximum Environmental Noise Levels, for construction noise ordinances. These levels are provided in Table 12 and are defined by three classes of property usage and the maximum noise levels allowable for each.

For the purpose of discussing construction noise and potential construction noise impacts, this study used the WAC. The construction contracts would contain sections specific to construction noise and address any site-specific requests for variances or other construction-related noise issues associated with the East Link Project.

The State of Washington has also developed a set of construction-specific allowable noise-level limits that would apply to the construction of the East Link Project. These construction noise regulations are organized by type of noise and include general construction equipment; impulse equipment, such as jackhammers and pile drivers; haul trucks; and safety alarms, such as back-up beepers.

4.4.1 Washington State Construction Noise Regulation

Most project construction can be performed within the limits of the WAC noise ordinance if the work is conducted during normal daytime hours. If construction is performed during nighttime hours, the contractor must meet the noise-level requirements presented in Table 12 or get a noise variance from the governing jurisdiction. Besides the property line noise standards in Table 12, there are exemptions for short-term noise exceedances, including those outlined in Table 13 that are based on the minutes per hour that the noise limit is exceeded.

TABLE 12
Washington State Noise Control Regulation

Land Use	Maximum Allowable Sound Level in dBA[a]		
	Residential	Commercial	Industrial
Residential	55	57	60
Commercial	57	60	65
Industrial	60	65	70

[a] Between 10 p.m. and 7 a.m. the levels given above are reduced by 10 dBA.

TABLE 13
Exemptions for Short-Term Noise Exceedances

Minutes Per Hour	Adjustment to Maximum Sound Level
15	+5 dBA
5	+10 dBA
1.5	+15 dBA

4.4.2 Haul Truck Criteria

Maximum permissible sound levels for haul trucks on public roadways are limited to 86 dBA for speeds of 35 miles per hour (mph) or less, and 90 dBA for speeds over 35 mph when measured at 50 feet. For trucks operating at staging areas, the general construction equipment would be used to determine compliance.

4.4.3 Alarm Criteria

Sounds created by backup alarms are exempt if operated for less than 30 minutes per incident, except between 10 p.m. and 7 a.m. when "beep-beep" backup alarms are prohibited and would be replaced with smart back-up alarms, which automatically adjust the alarm level based on the background level or switch off back-up alarms and replace with spotters

4.5 Construction Vibration Criteria

Construction vibration, unlike vibration from operations, has the potential to cause damage to structures at very close distances, from activities such as blasting and pile driving. Because of this, the construction vibration discussion includes both annoyance impact criteria and damage criteria.

Generally, because of the short duration of construction vibration activities, annoyance is usually not an issue. For longer-term activities, such as tunneling and associated muck train use, annoyance impact would be addressed. When vibration and associated ground-borne noise are assessed for particular construction activities, the transit vibration impact criteria are used to determine the potential for impact. Because the transit vibration criteria are based on the frequency of events, it is important to know the frequency of events for a particular construction activity.

In order to assess the potential for damage from construction activities, criteria in terms of PPV (as discussed in Section 2.2) have been developed based on the building type (Swiss Consultants for Road

Construction Association, 1992). These criteria include the following (vibration velocity levels are noted in parentheses):

- Reinforced concrete, steel, or timber – 0.5 PPV (102 VdB)
- Engineered concrete and masonry – 0.3 PPV (98 VdB)
- Non-engineered timber and masonry buildings – 0.2 PPV (94 VdB)
- Buildings extremely susceptible to vibration damage – 0.12 VdB (90 VdB)

As can be seen from the corresponding vibration velocity levels in parentheses, the thresholds for damage for even the most sensitive buildings are 1 to 2 orders of magnitude higher than the criteria for annoyance from vibration.

5.0 Future Build Conditions

This section summarizes the models used to predict future noise and vibration levels for potential sources of community impact related to the East Link Project. These sources include light rail operation, changes in traffic due to the project, and construction activities.

5.1 Light Rail Noise Projections

Noise from light rail operations was modeled using the methods described in the FTA *Transit Noise and Vibration Assessment Manual*. Input to the model included the following:

- 9-minute to 10-minute headways during peak-hours, 10-minute headways during midday and early evening, and 15-minute headways during late evening, nighttime, and early morning hours. See Appendix E of the Draft Environmental Impact Statement (EIS) for a summary of the Operations Plan.
- Measured reference noise levels for the new light rail vehicles that are being used on the Central Link system, which have noise reducing wheel skirts. Curves of modeled Ldn and maximum noise level (Lmax) versus distance assuming a train speed of 50 mph are shown in Exhibit 17. (The noise projections in Exhibit 17 are corrected to account for speed, track type, and topographical conditions.)
- Digital terrain in 5-foot-elevation contour intervals.
- Plan and profile of the proposed light rail alternatives and design options, including the locations of special track work, such as crossovers, where wheel impacts make a clicking noise and vibration levels can be increased
- Proposed maximum speeds along each of alternatives/design options.
- Adjustments based on track type, as shown in Table 14.

Based on the results of the analysis provided in this chapter, noise impacts were determined for each alternative and for ancillary facilities. These impacts are identified in Chapter 6. Noise mitigation options were evaluated for all locations where the projected levels of noise exposure exceed the FTA noise impact thresholds. The noise mitigation measures for the alternatives are discussed in Chapter 7.

TABLE 14
Light Rail Track Type Adjustments

Track Type	Adjustment in dB
At-Grade Ballast and Tie Track, Ballast Exposed	0
Elevated Structure	+4
Embedded Track	+3
Retained Cut	-6
At-Grade Station	0
Crossover	+10

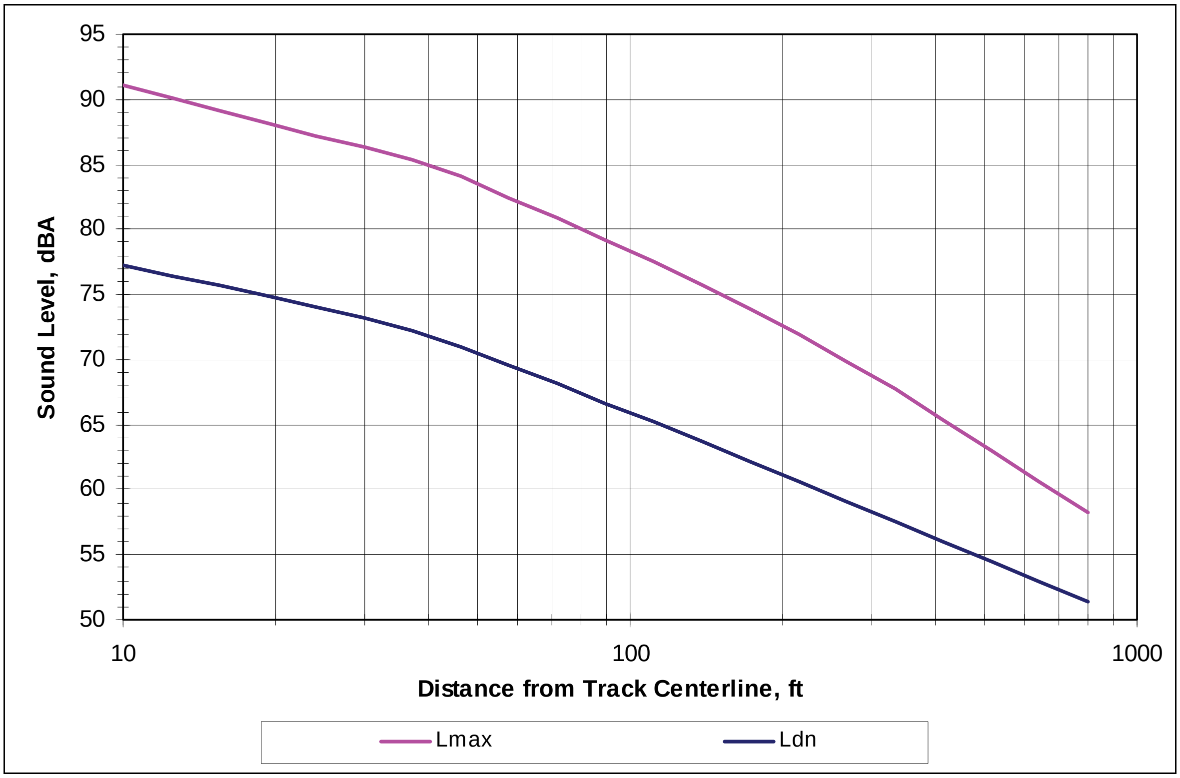


EXHIBIT 17
Projected Noise Levels from Light Rail Operations, 50 mph

5.2 Light Rail Vibration Projections

The projection of ground-borne vibration from East Link Project light rail operations was based on the following:

- Vibration source levels were based on measurement data for the Sound Transit light rail vehicle, as measured by Wilson Ihrig & Associates, Inc. (2007)
- Vibration propagation tests were conducted at representative sites along the corridor near sensitive receptors, as described in Section 3.3. The results of these tests were combined with the vehicle vibration source level measurement data to provide projections of vibration levels from vehicles operating on the East Link Project alternatives.
- Vehicle operating speeds were taken from the operations plans. The speeds are dependent on location, with a maximum operating speed of 55 mph.
- Wheel impacts at crossovers typically cause localized vibration increases of 10 VdB.

The assumed vehicle vibration characteristics (represented by the force density spectra in Exhibit 18) at the appropriate speeds were combined with the ground-vibration propagation test results described in Section 3.3 and represented by transfer mobility spectra such as those shown in Exhibits 11 through 13. Vibration levels were projected as a function of distance and speed for each of the eight test sites along the proposed corridor. The results of these transfer mobility tests are presented in Appendix D of this report. The results suggest dividing the rail corridor into eight regions for the purposes of vibration projection, defined based on the test sites as follows:

- Region 1 – Segment A (Site V-1)
- Region 2 – The southern section of Segment B (Site V-2)

- Region 3 – The northern section of Segment B and the at-grade and elevated alternatives for Segment C (Site V-3)
- Region 4 – The tunnel alternatives for Segment C (Site V-4)
- Region 5 – Overlake Hospital (Site V-5)
- Region 6 – Segment D (Site V-6)
- Region 7 – The southern portion of Segment E (Site V-7)
- Region 8 – The northern portion of Segment E (Site V-8)

The projections of maximum ground-vibration levels from light rail operations at 100 feet and 55 mph for each of the above eight regions are provided in Exhibits 19 through 21. The curve for each site has a different spectral characteristic, which determines the distance to each region. The results suggest that there is relatively inefficient propagation of vibration throughout the proposed corridor, which will limit potential vibration impacts. However, there is substantial energy at higher frequencies (i.e., above 50 Hz), which suggests the potential for ground-borne noise impacts in tunnel sections.

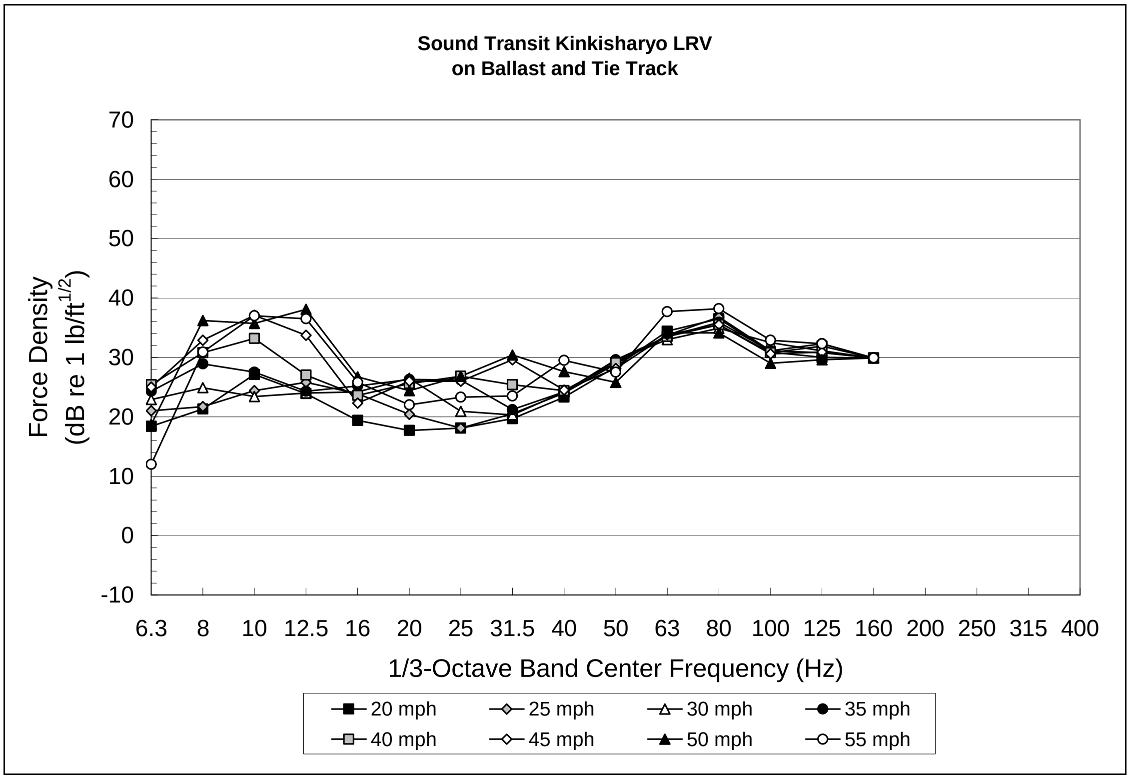


EXHIBIT 18
Light Rail Vehicle Force Density Spectra

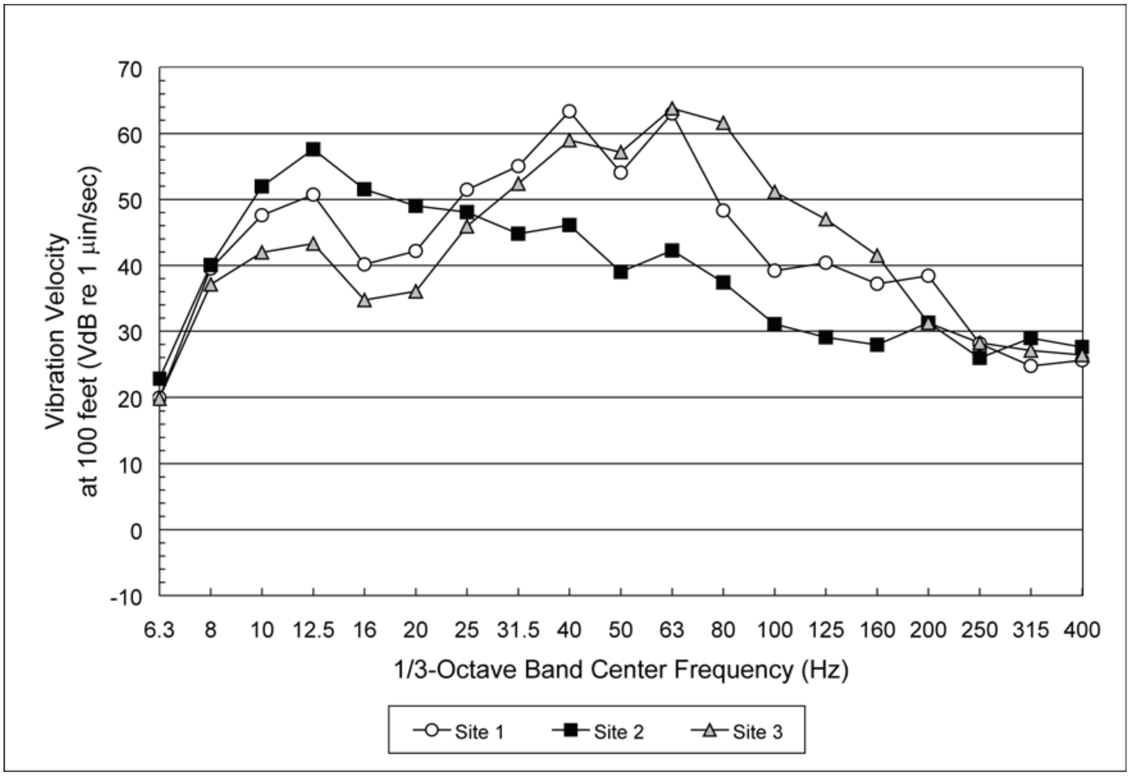


EXHIBIT 19
Projected Light Rail Ground Vibration Spectra at 55 mph, Sites V-1 to V-3

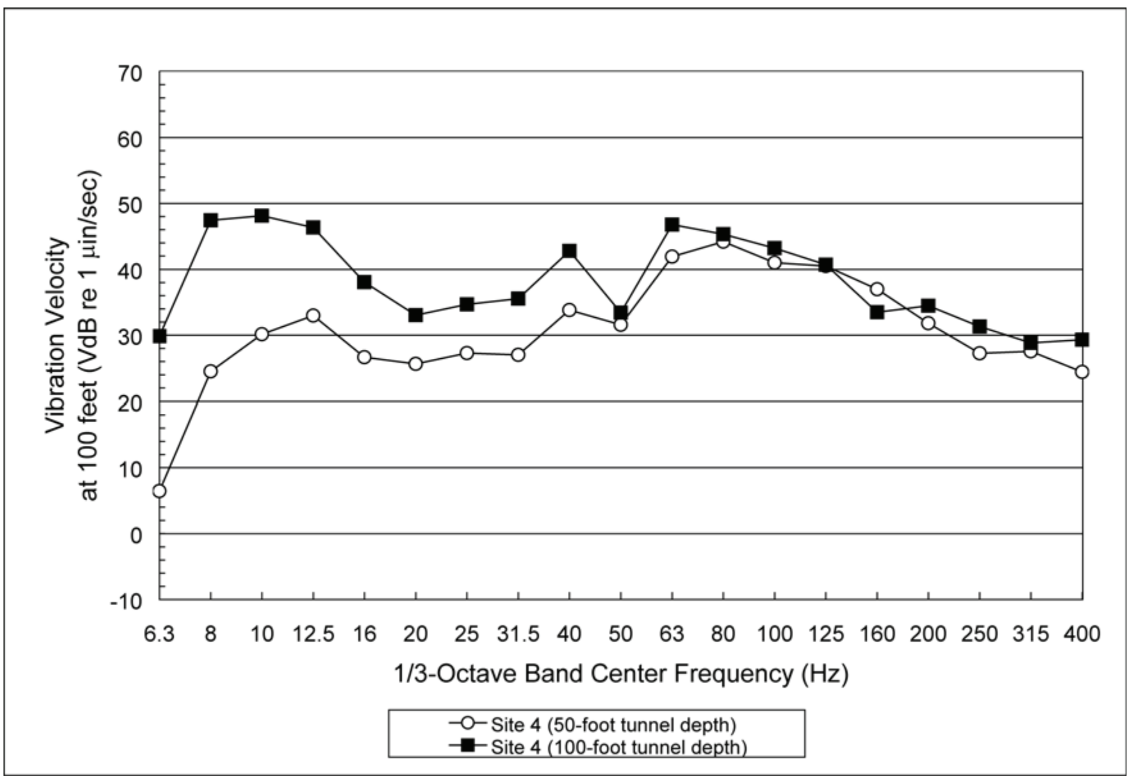


EXHIBIT 20
Projected Light Rail Ground Vibration Spectra at 55 mph, Site V-4

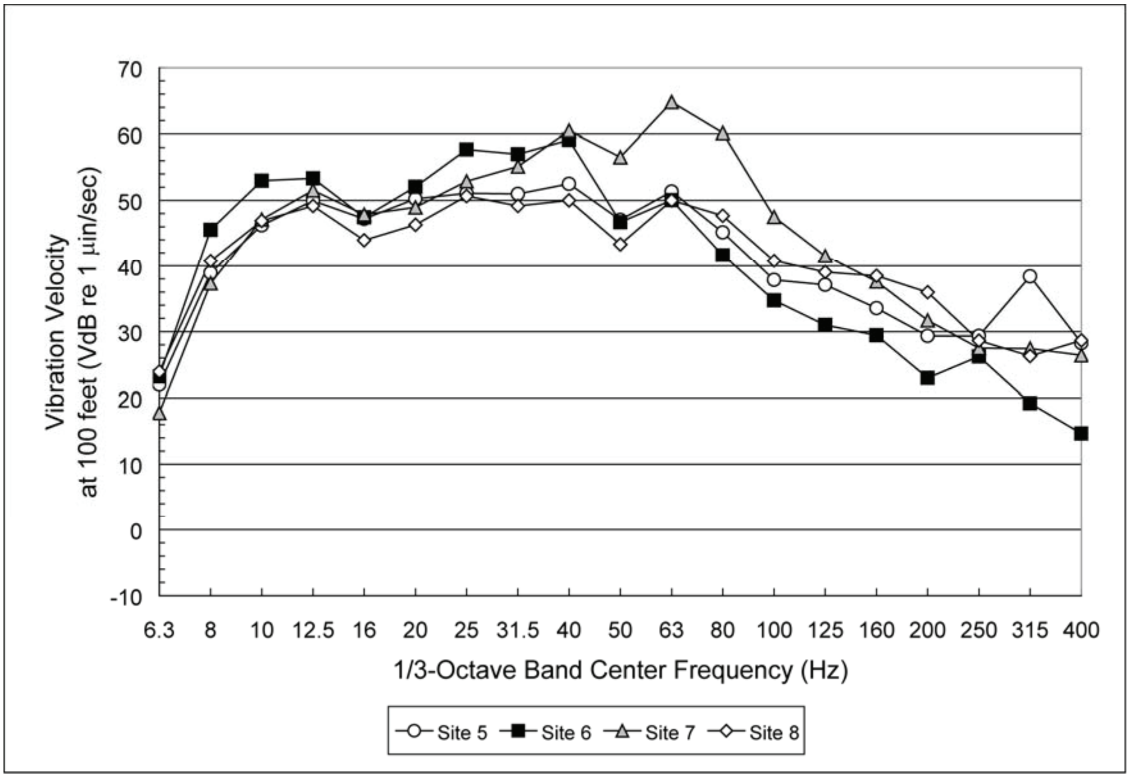


EXHIBIT 21
Projected Light Rail Ground Vibration Spectra at 55 mph, Sites V-5 to V-8

5.3 Construction Noise Projections

This analysis considers the temporary noise impacts that construction would cause in the project vicinity. These impacts would end when project construction is completed.

Noise and vibration related to construction would result from the operation of heavy equipment needed to construct various project components, including bridges, retaining walls, roads, park-and-ride lots, and stations. The contractor would be required to adhere to local ordinances regulating noise, discussed in Section 4.4. Construction outside normal weekday daytime hours may require a noise variance from the city or county where the work is being performed if regulatory noise levels are exceeded.

Equipment required to complete the project includes normal construction equipment typically used for transportation construction projects. Table 15 provides a list of the typical equipment used for this type of project, the activities they would be used for, the corresponding Lmax that would be produced as measured at 50 feet, under normal use.

TABLE 15
Construction Equipment List, Reference Noise Levels

Equipment	Expected Project Use	Lmax[a, b] (dBA)
Air Compressors	Pneumatic tools and general maintenance, all phases	70 – 76
Backhoe	General construction and yard work	78 - 82
Concrete Pump	Pumping concrete	78 - 82
Concrete Saws	Concrete removal, utilities access	75 - 80

TABLE 15
Construction Equipment List, Reference Noise Levels

Equipment	Expected Project Use	Lmax[a, b] (dBA)
Crane	Materials handling, removal, and replacement	78 - 84
Excavator	General construction and materials handling	82 - 88
Forklifts	Staging area work and hauling materials	72
Haul Trucks	Materials handling, general hauling	86
Jackhammers	Pavement removal	74 - 82
Loader	General construction and materials handling	86
Pavers	Roadway paving	88
Pile Drivers	Support for structure and hillside	99 - 105
Power Plants	General construction use, nighttime work	72
Pumps	General construction use, water removal	62
Pneumatic Tools	Miscellaneous construction work	78 - 86
Tractor Trailers	Material removal and delivery	86
Utility Trucks	General project work	72
Vibratory equipment	Shoring up hillside to prevent slides and soil compacting	82 - 88
Welders	General project work	76

[a] Typical maximum noise level under normal operation as measured at 50 feet from the noise source.

[b] Noise levels presented are based on measured data from the Portland Light Rail construction projects, I-5 Preservation and Hawthorn Bridge construction projects and other measured data and U.S DOT construction noise documentation and other construction noise sources

5.4 Construction Vibration Projections

Construction vibration, similar to noise, is highly dependent on the specific equipment and methods employed. There is a variety of potential effects that can be caused by construction vibration, including influence on vibration-sensitive equipment at lower levels, low rumbling or ground-borne noise, vibrations perceptible to humans at moderate levels, and slight damage to buildings at the highest levels. Generally, construction vibration was assessed at locations where prolonged annoyance or building damage could be expected.

In most cases, the main concern for construction vibration is the potential for damage. However, most construction processes do not generate high enough vibration levels to approach damage criteria. Because construction is a short-term, temporary impact, annoyance is usually not an important issue. The only time annoyance is usually addressed for construction vibration is for longer-term impacts, such as those related to the tunneling in Segment C. However, the thresholds for annoyance from construction vibration are substantially lower than those for damage.

Damage from construction vibration is generally limited to pile driving and vibratory rolling, the only two activities with PPV levels at 25 feet that are higher than the damage criteria discussed in Section 4.5, Construction Vibration Criteria. Because of this, care should be taken to limit these activities near structures as much as possible.

Tunnel construction in Segment C is most likely to have potential temporary, short-term vibration annoyance impacts. Some sections of the proposed tunnel alternatives are expected to be constructed using a tunnel-boring machine with muck trains to transport the excavated material. Other tunnel sections and stations would use cut-and cover techniques with sheet piling or augered pile techniques at the stations and portals.

The methodology for assessing construction vibration annoyance impacts is consistent with the approach provided in the FTA guidance manual, which includes obtaining reference 1-second rms overall vibration levels and 1/3-octave band spectra for each source at a distance of 25 feet. The propagation of vibration as a function of distance is an important factor in predicting vibration levels. Generally, surface or bore-hole-based vibration propagation measurements at the specific sensitive sites are needed to provide a detailed assessment. The following general prediction model is used to calculate vibration levels at the sensitive locations in each 1/3-octave band using the following propagation adjustment:

$$Lv(\text{Distance}) = Lv(25\text{ feet}) - 30 \cdot \text{Log}(\text{Distance}/25\text{ feet})$$

Adjustment factors are then applied according to the geological conditions that could promote efficient vibration propagation, coupling to the building foundation, floor-to-floor attenuation, and the amplification of vibrations due to the resonances of floors, walls, and ceilings. Vibration levels at the sensitive locations are then assessed against the vibration criteria for detailed analysis at highly sensitive locations shown in Table 11.

In accordance with FTA guidance, ground-borne noise is assessed by converting the 1/3-octave band vibration velocity levels into A-weighted noise levels. Assessment of ground-borne noise levels only applies to human annoyance because research equipment and other receptors are rarely sensitive to noise. The predicted A-weighted noise levels are then assessed against the ground-borne noise impact criteria shown in Tables 9 and 10.

6.0 Noise and Vibration Impact Assessment

A detailed noise and vibration impact assessment was performed based on the criteria discussed in Chapter 4 of this report and on the projections described in Chapter 5 of this report. The assessment results are described below.

6.1 Light Rail and Traffic Noise Impact Assessment

Evaluation of the environmental noise effects of the East Link alternatives was based upon the change in the environmental noise level due to each project alternative and the number of dwelling units potentially affected by project noise. The transit noise methodology is consistent with the FTA *Transit Noise and Vibration Manual*. The FTA noise assessment methodology was also applied to the park-and-ride facilities and transit centers.

6.1.1 Transit Noise

East Link Project light rail noise impacts were determined using the following approach:

- Perform a land-use survey of potential noise-sensitive receptors in the vicinity of the project alternatives. This process involved site visits and review of area land-use maps. Receivers located near each other and at the same distance from the proposed light rail alternatives were grouped together in clusters. All of the receivers in a given cluster would be within the same distance of light rail tracks and under similar conditions (such as track type and train speed); they would therefore have the same noise exposure.
- Establish existing noise levels for the potentially affected area through long-term (24-hour) and short-term (20-minute periods) noise monitoring. Ambient noise monitoring data from previous studies was used along with supplemental data taken specifically for this project. The criteria for monitoring selection included land use, existing ambient noise, number of sensitive receivers in the area, and level of expected impact.
- Use the field-noise measurements to project ambient sound levels for the noise-sensitive receptors, based on similarities in noise-source characteristics.
- Use the existing ambient sound levels to determine the noise impact criteria at each cluster. The FTA criteria for noise impacts for a particular area are based on the existing noise level.
- Make projections of light rail noise levels based on track type, train speed, vehicle type, and distance of receiver from tracks, with adjustments for shielding and ground attenuation.
- Compare projections to impact thresholds to determine if the receiver or cluster would be impacted by light rail operations.
- Where noise impacts are identified, consider mitigation.

6.1.2 Traffic Noise

Traffic noise was analyzed using the WSDOT methods given in the *Traffic Noise Abatement Policy and Procedures* (WSDOT, 2006). Traffic noise was only evaluated where required by FTA and FHWA, where the following conditions apply:

- There is a new roadway planned as part of the project
- The project results in a significant change in the horizontal or vertical profile of an existing roadway

- An increase in the number of through-traffic lanes

Existing and future year 2030 peak-hour traffic noise levels were calculated using FHWA Traffic Noise Model (TNM) Version 2.5. Input to this model included traffic-volume and speed information from roadway traffic counts and data generated by Sound Transit traffic engineers. Input to the model relating to the existing and future roadway alignments and profiles was taken from engineering drawings and aerial photographs prepared by Sound Transit for this project. Traffic-noise emission levels used in the model were nationwide averages for automobiles, medium trucks, and heavy trucks. The noise-reducing effects of adjacent residences, roadway depressions, and topography were included in the calculations where appropriate. Project-related traffic noise impacts were identified by evaluating the TNM 2.5 model output against the traffic noise impact criteria. Noise monitoring data were used to validate the model.

6.1.3 Segment A

Segment A begins in the existing transit tunnel and continues along the I-90 D2 Roadway, remaining in the existing I-90 corridor to the I-90 Mt. Baker tunnel portals. Noise levels from rail operations in Seattle were projected for the residential area along Sturgus Avenue S, residences located north of S Massachusetts Street, and at residences and parklands near the Mount Baker Tunnel. Projected project-related noise levels ranged from 49 to 56 dBA Ldn at residences and 59 dBA Leq at Judkins Park and Playfield. Noise from the light rail operations is not projected to cause a substantial change in the overall noise levels in any of these areas, as I-90 will continue to be the dominant noise source. No noise impacts were identified in the Seattle portion of Segment A.

On Mercer Island, noise projections were performed for the residences located on the west end of Mercer Island, to the I-90 lid, and near the east end of the island. Future project-related noise levels would range from 47 dBA Ldn to 53 dBA Ldn at the nearest homes on the west end of the island. As with Seattle, there is no projected change in the noise levels at any residences on Mercer Island, and no light rail noise impacts were identified. Tables of the modeled light rail noise levels are provided in Appendix E of this report.

Installation of light rail on the I-90 floating bridge would require use of expansion joints at each end of the floating bridge structure, which could create noise. This supplemental analysis is available in Appendix F of this report. The expansion joints are not predicted to cause noise impacts above the FTA criteria because of the 700- to 800-foot distance to noise-sensitive properties. No new roadways or traffic-capacity increases planned in Segment A, and therefore no project-related traffic noise impacts are predicted.

6.1.4 Segment B

A summary of noise impacts in Segment B is provided in Table 16, followed by a detailed description of the impacts for each alternative. No transit or traffic noise impacts were identified for the 112th SE Elevated (B2E) Alternative. Transit noise impacts would only occur for the Bellevue Way (B1) and BNSF (B7) alternatives; traffic noise impacts would only occur for the 112th SE At-Grade (B2A), the 112th SE Bypass (B3), and B1 alternatives, due to changes in the travel lanes in relation to sensitive receptors.

TABLE 16
Summary of Potential Noise Impacts for Segment B

Alternative	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
B1, Bellevue Way	None	3 SF	41 SF residences and 39 MF units
B2A, 112th SE At-Grade	None	None	20 SF residences
B2E, 112th SE Elevated	None	None	None
B3, 112th SE Bypass	None	None	20 SF residences
B7, BNSF	59 MF units	39 MF units	None

Notes:
SF = single family
MF = Multifamily

6.1.4.1 Bellevue Way Alternative (B1)

Three severe light rail noise impacts were identified for the Bellevue Way Alternative (B1), all of which would be located near the double crossover at SE 30th Street. The noise impacts would be directly related to the additional noise from the crossover. Table 17 provides a summary of the light rail noise impacts and projected future noise levels without noise mitigation. Full tables of all modeled light rail noise levels are in Appendix E.

TABLE 17
Segment B Light Rail Noise Impacts

Alternative	Site Description	Modeled Existing Noise Level (Ldn)	Criteria		Number of Residential Units and Type of Impact	Future Noise Level (Ldn)
			Moderate	Severe		
B1, Bellevue Way	SE 30th Street Intersection	69	64	69	3 SF residences- severe impacts	73
B7, BNSF	MF units near I-405	64	60	66	36 MF units -severe impacts	69
	MF units near I-405	64	60	66	11 MF units - moderate impacts	66
	MF units near I-405	64	60	66	24 MF units - moderate impacts	66
	MF units near I-405	60	58	63	18 MF units – moderate impacts	62
	MF units near I-405	60	58	63	3 MF units – severe impacts	65
	MF units near I-405	60	58	63	6 MF units -moderate impacts	62

Notes:
SF = single family
MF = multifamily

For B1, traffic noise levels were projected using PM peak-hour traffic volumes at 31 representative receiver locations. The 31 receivers were used to evaluate traffic noise levels at up to 170 noise-sensitive properties along Bellevue Way. Receivers that would exceed the FHWA traffic noise criteria due to the

project are listed in Table 18, which includes existing and future build noise levels. A complete table with the existing, future no-build, and future build noise levels is located in Appendix E of this report.

TABLE 18
Segment B Traffic Noise Impacts

				Existing Levels		No Build Levels		Build Levels			
Alternative	**Rec #**	**Dwellings[a]**	**WSDOT Criteria[b]**	**Peak Hour Leq**	**No. of Impacts**	**Peak Hour Leq**	**No. of Impacts**	**Peak Hour Leq**	**No. of Impacts**	**Change from Existing Leq**	**Change from No-Build Leq**
B1, Bellevue Way	R-1	3 SF	66	66	3 SF	68	3 SF	69	3 SF	+ 3	+ 1
	R-4	5 SF	66	65	--	67	5 SF	68	5 SF	+ 3	+ 1
	R-7	5 SF	66	66	5 SF	68	5 SF	68	5 SF	+ 2	0
	R-8	8 SF	66	66	8 SF	68	8 SF	72	8 SF	+ 6	+ 4
	R-12	1 SF	66	65	--	67	1 SF	65	--	0	- 2
	R-14	4 SF	66	67	4 SF	69	4 SF	72	4 SF	+ 5	+ 3
	R-16	3 SF	66	70	3 SF	72	3 SF	74	3 SF	+ 4	+ 2
	R-18	16 MF	66	63	--	66	16 MF	68	16 MF	+ 5	+ 2
	R-23	4 MF 2 SF	66	64	--	67	4 MF 2 SF	67	4 MF 2 SF	+ 3	0
	R-26	3 SF	66	63	--	65	--	67	3	+ 4	+ 2
	R-27	2 MF 7 SF	66	66	2 MF 7 SF	68	2 MF 7 SF	70	2 MF 7 SF	+ 4	+ 2
	R-31	18 MF	66	66	18 MF	69	18 MF	68	18 MF	+ 2	- 1
		Total		**Min/Max**	**Total**	**Min/ Max**	**Total**	**Min/ Max**	**Total**	**Min/Max**	**Min/Max**
		40 MF 41 SF		**63/70[c]**	**20 MF 30 SF**	**65/72**	**40 MF 38 SF**	**66/74[c]**	**40 MF 40 SF**	**0/+6**	**-2/+4**
B2A, 112th SE At-Grade B3, 112th SE Bypass	R-8	8 SF	66	66	8 SF	68	8 SF	72	8 SF	+ 6	+ 4
	R-11	5 SF	66	66	5 SF	68	5 SF	68	5 SF	+ 2	0
	R-14	4 SF	66	67	4 SF	69	4 SF	70	4 SF	+ 3	+ 1
	R-16	3 SF	66	70	3 SF	72	3 SF	72	3 SF	+ 2	0
		Total		**Min/Max**	**Total**	**Min/ Max**	**Total**	**Min/ Max**	**Total**	**Min/Max**	**Min/Max**
		20 SF		**65/70**	**20 SF**	**67/72**	**20 SF**	**66/72**	**20 SF**	**+2/+6**	**0/+4**

[a] Number of residential units with the same noise level.

[b] WSDOT traffic noise impact criteria from Section 4.1.2.

[c] Existing modeled noise levels and number of noise impacts.

[d] Future build modeled noise levels, change in noise versus existing, number of noise impact and noise level change compared to No Build Alternative.

Currently, there are an estimated 50 residences that meet or exceed the WSDOT traffic noise abatement criteria; for the No Build Alternative, that number is projected to increase to 78. For the Bellevue Way Alternative (B1) the number of residences projected to exceed the impact criteria is 80. Existing modeled traffic noise levels along the corridor ranged from 57 to 70 dBA Leq (see Appendix E for noise measurements at all locations). For B1, the noise levels are projected to increase by up to 4 dBA from the

No Build Alternative and to range from 57 to 74 dBA. There are several locations where noise levels would decrease slightly (by 1 to 2 dB) due to roadway realignment, although changes of this magnitude are not normally discernable by the average person.

It is also important to note that the three residences with light rail noise impacts near the double crossover on Bellevue Way at 113th Avenue SE also exceed the traffic noise impact criteria. These light rail noise impacts are included with the five homes represented by receiver R4 in Table 18.

6.1.4.2 112th SE At-Grade Alternative (B2A)

For the 112th SE At-Grade Alternative (B2A) no light rail noise impacts were identified. The Ldn is not projected to increase by more than 1 dB at any noise-sensitive properties along the corridor. Light rail operational noise levels are predicted to range from 51 to 63 dBA Ldn at noise-sensitive properties along Bellevue Way and 112th Avenue SE. Complete modeled results are provided in Appendix E of this report.

B2A would require some roadway widening along Bellevue Way, between the South Bellevue Station and the 112th Avenue SE intersection. Along 112th Avenue SE, B2A would replace the existing median, and minimal roadway modifications would be required. Improvements on Bellevue Way would be similar to the Bellevue Way Alternative (B1). Existing and future noise levels with the project along Bellevue Way are provided in Table 18. A table with the complete existing, future no-build, and future project noise levels is included in Appendix E of this report.

Currently, 20 residences have traffic noise levels above the WSDOT criteria. For the No Build Alternative, the number of impacts would stay the same, but noise levels would increase by up to 6 dBA Under the 112th SE At-Grade Alternative (B2A), the same impacts would also still occur, but the maximum increase would be 4 dBA.

6.1.4.3 112th SE Elevated Alternative (B2E)

Noise projections and complete tabulated modeled noise levels for B2E are included in Appendix E of this report. No light rail noise impacts were identified for the 112th SE Elevated Alternative (B2E). B2E would require no substantial changes in the roadway alignments; therefore, no traffic noise impacts are projected.

6.1.4.4 112th SE Bypass Alternative (B3)

No light rail noise impacts were identified for the 112th SE Bypass Alternative (B3). Detailed tables of light rail noise levels are provided in Appendix E of this report. Traffic noise impacts under B3 are the same as those provided in Section 6.1.4.2 for B2A.

6.1.4.5 BNSF Alternative (B7)

For the BNSF Alternative (B7), light rail noise impacts are projected at 98 multifamily units along the west side of the light rail route along 118th Avenue SE, 39 of which would have severe impacts and 59 of which would have moderate impacts. Thirty-six of the severe noise impacts would be due to the nearby crossover. Table 17 provides a summary of the light rail noise projections and impacts. Complete tabulated modeled noise levels for B7 are provided in Appendix E of this report. B7 would require no substantial changes in the roadway alignments; therefore, no traffic noise impacts are projected.

6.1.5 Segment C

A summary of light rail noise impacts in Segment C is provided in Table 19, followed by a detailed description of the impacts for each alternative. Noise impacts from traffic were identified for the Bellevue Way Alternative (C1T) only, and are discussed under that alternative. The remaining Segment C alternatives did not substantially change the existing roadway alignments and therefore no traffic noise impacts were identified for these alternatives.

TABLE 19
Summary of Potential Noise Impacts for Segment C

Alternative	Connection (from Alternative)	Moderate Light Rail Impacts	Severe Light Rail Impacts	Traffic Noise Impacts
C1T, Bellevue Way Tunnel	B1, Bellevue Way	12 MF units	None	21 MF units
C2T, 106th NE Tunnel	B2A, 112th SE At-Grade	12 MF units	None	None
	B2E, 112th SE Elevated	12 MF units	18 Hotel rooms 6 SF units	None
	B3, 112th SE Bypass; or B7, BNSF	12 MF units 4 Hotel rooms	None	None
C3T, 108th NE Tunnel	B2A, 112th SE At-Grade	None	None	None
	B2E, 112th SE Elevated	None	18 Hotel rooms 2 SF units 4 MF units	None
	B3, 112th SE Bypass; or B7, BNSF	4 Hotel rooms	None	None
C4A, Couplet	B2A, 112th SE At-Grade	12 MF units	None	None
	B2E, 112th SE Elevated	None	6 MF units	None
	B3, 112th SE Bypass; or B7, BNSF	4 Hotel rooms	None	None
C7E, 112th SE Elevated	B2A, 112th SE At-Grade	None	2 SF units 10 MF units	None
	B2E, 112th SE Elevated	None	2 SF units 4 MF units	None
	B3, 112th SE Bypass; or B7, BNSF	4 Hotel rooms	None	None
C8E, 110th NE Elevated	B3, 112th SE Bypass; or B7, BNSF	80 MF units 3 SF units 4 Hotel rooms	None	None

Notes:
SF = single family
MF = multifamily

6.1.5.1 Bellevue Way Tunnel Alternative (C1T)

The only light-rail-related noise impact predicted for the Bellevue Way Tunnel Alternative (C1T) occurs at the multifamily units on Lake Bellevue. Up to 12 units are predicted to exceed the FTA impact criteria. The impacts would occur along the elevated section on 118th Avenue NE and exceed the FTA criteria by 1 dB. Table 20 summarizes the noise projections. Complete tabulated modeled noise levels for C1T are included in Appendix E of this report.

TABLE 20
Segment C Light Rail Noise Impacts

Alternative and Connection		Site Description	Modeled Existing Noise Level (Ldn)	Criteria: Moderate	Criteria: Severe	Impact Description	Future LRT Modeled Noise Level (Ldn)
C1T, Bellevue Way		MF units at Lake Bellevue	60	58	63	12 MF units-moderate impacts	63
C2T, 106th NE Tunnel	112th SE At-Grade (B2A), 112th SE Bypass (B3), BNSF (B7)	MF units at Lake Bellevue	60	58	63	12 MF units-moderate impact	63
	112th SE Elevated (B2E)	Hotel Rooms on 112th Avenue SE	69	64	69	18 hotel rooms-severe impacts	72
		SF residences on 112th Avenue SE	72	64	69	2 SF residences - severe impacts	74
		MF residences on 112th Avenue SE	72	64	69	4 MF units - severe impacts	74
		MF units at Lake Bellevue	60	58	63	12 MF units-moderate impact	63
	112th SE Bypass (B3), BNSF (B7)	Hotel Rooms on 114th Avenue SE	74	66	72	4 Hotel rooms-moderate impact	65
C3T, 108th NE Tunnel	112th SE At-Grade (B2A)	0	0	0	0	0	0
	112th SE Elevated (B2E)	Hotel Rooms on 112th Avenue SE	69	64	69	18 hotel rooms-severe impacts	72
		SF residences on 112th Avenue SE	72	64	69	2 SF residences - severe impacts	74
		MF residences on 112th Avenue SE	72	64	69	4 MF units - severe impacts	74
	112th SE Bypass (B3), BNSF (B7)	Hotel Rooms on 114th Avenue SE	74	66	72	4 Hotel rooms-moderate impact	65
C4A, Couplet	112th SE At-Grade (B2A)	Near Main Street and crossover	69	64	69	12 MF units-moderate impacts	72
	112th SE Elevated (B2E)	Near Main Street and crossover	71	64	69	6 MF units-severe impacts	74
	112th SE Bypass (B3), BNSF (B7)	Hotel Rooms on 114th Avenue SE	74	66	72	4 Hotel rooms-moderate impact	65

TABLE 20
Segment C Light Rail Noise Impacts

Alternative and Connection		Site Description	Modeled Existing Noise Level (Ldn)	Criteria		Impact Description	Future LRT Modeled Noise Level (Ldn)
				Moderate	Severe		
C7E, 112TH NE Elevated	112th SE At-Grade (B2A)	Near Main Street and crossover	72	64	69	2 SF residences - severe impacts 10 MF units- severe impacts	74
	112th SE Elevated (B2E)	Near Main Street and crossover	71	64	69	2 SF residences - severe impacts 4 MF units- severe impacts	74
	112th SE Bypass (B3), BNSF (B7)	Hotel Rooms on 114th Avenue SE	74	66	72	4 Hotel rooms- moderate impact	65
C8E, 110th NE Elevated	112th SE Bypass (B3), BNSF (B7)	MF Units on NE 110th Avenue	63	61	67	80 moderate MF impacts	68
			63	61	67		68
			64	61	67		68
		SF units north of NE 12th Street	64	60	66	3 moderate SF noise impacts	67
			62	59	64		65
		Hotel Rooms on 114th Avenue SE	74	66	72	4 Hotel rooms- moderate impact	65

Notes:
SF = single family
MF = multifamily

For the Bellevue Way Tunnel Alternative (C1T), the roadway would be widened, moving the traffic lanes closer to several properties. This results in traffic noise impacts on 21 multifamily units along Bellevue Way near the connection to Segment B (see Table 21).

TABLE 21
Segment C Traffic Noise Impacts

Alternative	Rec #	Dwellings[a]	WSDOT Criteria[b]	Existing Levels		No Build Levels		Build Levels			
				Peak Hour Leq	No. of Impacts	Peak Hour Leq	No. of Impacts	Peak Hour Leq	No. of Impacts	Change from Existing Leq	Change from No-Build Leq
C1T, Bellevue Way Tunnel	R32	21 MF	66	66	21	69	21	68	21	+ 2	- 1

[a] Number of residential units with the same noise level.
[b] WSDOT traffic noise impact criteria from Section 4.1.2.
[c] Existing modeled noise levels and number of noise impacts.
[d] Future build modeled noise levels, change in noise versus existing, number of noise impact and noise level change compared to No Build Alternative.

6.1.5.2 106th NE Tunnel Alternative (C2T)

There are 12 moderate light rail noise impacts to multifamily units at Lake Bellevue projected under the 106th NE Tunnel Alternative (C2T) for all connections to Segment B. In addition to these 12 impacts, C2T would have severe noise impacts at 18 hotel units, two single-family residences, and four multifamily units located on 112th Avenue SE when connecting to the 112th SE Elevated Alternative (B2E). The severity of the predicted noise impacts are related to the proximity of the double crossover on 112th Avenue SE. Table 20 summarizes these noise projections. When connecting to the 112th SE Bypass (B3) or the BNSF (B7) alternatives, C2T would have a moderate impact to four hotel rooms along 114th Avenue SE. Complete tabulated modeled noise levels for C2T are included in Appendix E of this report.

6.1.5.3 108th NE Tunnel Alternative (C3T)

No light rail noise impacts were identified under the 108th NE Tunnel Alternative (C3T) connecting from the 112th SE At-Grade Alternative (B2A). Under C3T from the 112th SE Elevated Alternative (B2E), there would be severe noise impacts at 18 hotel units, two single-family residences, and four multifamily units located on 112th Avenue SE. The severity of these noise impacts is related to the proximity of the double crossover on 112th Avenue SE. When connecting to the 112th SE Bypass (B3) or the BNSF (B7) alternatives, C3T would have a moderate impact to four hotel rooms along 114th Avenue SE. Table 20 summarizes these noise projections. C3T would require no substantial changes in the roadway alignments; therefore, no traffic noise impacts are projected. Table 21 provides the modeling results for C3T.

6.1.5.4 Couplet Alternative (C4A)

For the Couplet Alternative (C4A) connecting from the 112th SE At-Grade Alternative (B2A), there would be 12 moderate multifamily noise impacts due to the Project. For C4A from the 112th SE Elevated Alternative (B2E), there would be six severe noise impacts, and for the connections from 112th SE Bypass (B3) and BNSF (B7) alternatives, there would be moderate impacts to four hotel rooms along 114th Avenue SE. Table 20 provides the modeled noise levels for C4A from all connectors. The projected noise impacts under C4A mainline are along 112th Avenue SE and are due to the location of crossover tracks. Complete tabulated modeled noise levels for all receivers regardless of impact for C4A are included in Appendix E of this report.

6.1.5.5 112th NE Elevated Alternative (C7E)

Several severe noise impacts are projected for the 112th NE Elevated Alternative (C7E). Along 112th Avenue SE there would be 12 severe noise impacts at single-family and multifamily residential units south of Main Street for the connection from the 112th SE At-Grade Alternative (B2A). When connecting from the 112th SE Elevated Alternative (B2E), the number of impacts would be reduced to six severe noise impacts at two single-family and four multifamily units on 112th Avenue SE. These noise impacts are due to the location of crossover tracks on 112th Avenue SE. When connecting to the 112th SE Bypass (B3) or the BNSF (B7) alternatives, C7E would have a moderate impact to four hotel rooms along 114th Avenue SE. Complete tabulated modeled noise levels for C7E are included in Appendix E of this report.

6.1.5.6 110th NE Elevated Alternative (C8E)

Moderate light rail related noise impacts were identified at an estimated 80 multi-family units and hotel rooms along NE 110th Avenue between NE 8th Street and NE 12th Street along the elevated structure. Moderate light rail related noise impacts are also projected at four hotel rooms along 114th Avenue SE and three single-family structures on the north side of NE 12th Street. Table 20 provides the noise impact analysis results for C8E. Complete tabulated modeled noise levels for C8E are included in Appendix E of this report.

6.1.6 Segment D

The only noise impacts in Segment D would occur under the SR 520 Alternative (D5) and would be from light rail operation. No traffic noise impacts would occur in this segment. The projected noise impacts were identified at a multifamily residential structure just south of SR 520 and north of Northup Way on NE 21st Place. The severe impact would be to 10 units, as shown in Table 22. The proposed Children's Hospital was also evaluated, and no noise impacts were projected. No other noise impacts were identified in Segment D because most land use in this segment is commercial.

TABLE 22
Segment D Light Rail Noise Impacts

Alternative	Site Description	Modeled Existing Noise Level (Ldn)	Criteria		Impact Description	Future Noise Level (Ldn)
			Moderate	Severe		
D5, SR 520	Multifamily units near SR 520	68	65	71	10 moderate MF noise impacts	73

6.1.7 Segment E

Light rail noise impacts in Segment E would occur only under the Redmond Way Alternative (E1), as shown in Table 23. The Segment E alternatives would not substantially change the existing roadway alignments and therefore no traffic noise impacts were identified for these alternatives. No noise impacts are projected for the Marymoor (E2) or Leary Way (E4) alternatives.

The Redmond Way Alternative (E1) would cause moderate noise impacts at the multifamily residences on 156th Place NE, above West Lake Sammamish Parkway. The elevated profile of E1 would be between 45 to 95 feet from the multifamily units, resulting in moderate noise impacts at all units facing the tracks. Table 23 provides a summary of the modeled noise levels. Complete tabulated modeled noise levels for Segment E are provided in Appendix E of this report.

TABLE 23
Light Rail Noise Impacts, Redmond Way Alternative (E1)

Site Description	Modeled Existing Noise Level (Ldn)	Criteria		Impact Description	Future Noise Level (Ldn)
		Moderate	Severe		
MF units at 156 Place NE	63	60	66	20 MF – moderate noise impacts	67
	64	60	66	6 MF – moderate noise impacts	67

Notes:
MF = multifamily

6.1.8 Wheel Squeal

Wheel squeal is caused by the oscillation of the wheel against the rail on curved sections of rail. Wheel squeal noise levels were measured on the Tri-Met light rail system in Portland, Oregon, and were used for reference. Based on these measurements, curves with a radius of less than 300 feet have the ability to produce maximum noise levels of 83 to 85 dBA at 50 feet. The highest noise levels typically occur on tight radii curves of less than 100 to 150 feet.

The project corridor was investigated for locations with tight radii curves where wheel squeal could occur. In Segments A and B there are no curves with a radius of less than 300 feet, so no wheel squeal is projected. There are several locations in Segment C with tight radius curves, including the Couplet (C4A), 112th NE Elevated (C7E), and 110th NE Elevated (C8E) alternatives. Areas with tight radii curves in Segment D include the NE 16th At-Grade (D2A), NE 16th Elevated (D2E), and NE 20th (D3) alternatives connecting from the Bellevue Way Tunnel (C1T) and 106th NE Tunnel (C2T) alternatives. There is also a potential for wheel squeal for D2A, D2E, and D3 on 136th Place NE and at the intersection of NE 20th Street and 152nd Avenue NE. There is the potential for wheel squeal in Segment E under the Marymoor Alternative (E2) along 161st Avenue NE and near Redmond Way at SR 520 for all alternatives.

There has been substantial research into methods of reducing wheel squeal noise, and non-oil based lubricants, including water, have been found to be very effective at reducing or eliminating wheel squeal. The lubricants can be applied by personnel working trackside or by an automated applicator. Because the East Link Project would maintain a method of reducing or eliminating wheel squeal if it were to occur, no wheel squeal impacts are projected.

6.1.9 Maintenance Facility Alternatives

All potential maintenance facilities would be located in established industrial and commercial areas. Although residences are located to the west of the 116th Maintenance Facility (MF1), there would be no impacts to these residences. No noise impacts are projected to occur from any of the operation and maintenance activities at any of the alternative locations.

6.1.10 Park-and-Ride Facilities and Stations

Most park-and-ride lots proposed as part of the East Link Project are at or near existing park–and-ride lots, and no noise impacts are projected. The Mercer Island, Overlake Village, and Redmond Transit Center park-and-ride lots would not change, while the South Bellevue and Overlake Transit Center park-and-ride lots would be expanded. The only new park-and-ride lots proposed would be at the 118th Station in Segment B (for the BSNF Alternative [B7] only) and at the 130th Station in Segment D (for the NE 16th At-Grade [D2A], NE 16th Elevated [D2E], and NE 20th [D3] alternatives). These new and expanded park-and-ride lots are not projected to have noise impacts because there are no noise-sensitive receptors close enough to be impacted and because the lots are located in areas of high noise levels due to existing arterial traffic.

6.1.11 Freeway Noise at Proposed Freeway Stations

One additional noise assessment was conducted due to the unique position of some proposed stations in the center of or above a freeway in locations where freeway traffic noise may affect East Link patrons. This noise assessment only pertains to the Rainier and Mercer Island stations in Segment A and the Ashwood/Hospital Station in Segment C, where the station is directly above I-405. The detailed analysis is provided in Appendix F.

There are no federal standards for noise exposure from traffic noise on patrons at stations. Sound Transit has generally used a design goal of 72 dBA Leq (15-minute and 1-hour) for noise from exterior sources at station platforms. This The National Institute for Occupations Safety and Health (NIOSHA) standard for workplace noise exposure is 85 dBA for up to 8 hours, or 100 dBA for 15 minutes (NIOSHA, 1998). For comparison, measurements were taken at the SR 520 Montlake and Evergreen Road flyer stops which ranged from 76 to 89 dBA Leq at the Montlake flyer stop and 72 to 75 dBA Leq at the Evergreen flyer stop. The EPA states that communication at close proximity (2 to 4 feet) can be understood even with ambient noise levels of 72 to 78 dBA (EPA, 1974). It is unlikely that a patron would spend more than 15 minutes at an East Link station platform.

Based on bus flyer stop measurements and the short amount of time a person would spend at the station, Sound Transit will use a 78 dBA 15-minute Leq platform noise level goal for stations that are not able to meet the 72-dBA design goal due to traffic noise.

Traffic noise levels on I-90 and I-405 are loudest during the mid-day hours of 11 a.m. to 3 p.m. due to the higher speeds and level of truck traffic during these daytime hours. Peak commute traffic noise levels on these same highways are typically lower (by 2 to 3 dBA) due to reduced speeds associated with congested highways. Based on these factors, the maximum traffic noise levels during daytime hours were used in the analysis. The analysis also assumes the worst-case, 15-minute headways for the maximum time a person would spend at a platform.

Using typical daytime traffic volumes and speed provided by traffic engineers, a noise model was constructed using the FHWA TNM, which produces hourly Leq noise levels based on hourly traffic volumes. For transit stations near major highways, a short-term Leq measurement of 10 minutes is typically long enough to provide an accurate reading of the noise exposure. This is due to the relatively steady noise from passing vehicles on major highways such as I-90. Measurements at the Mercer Island and Ashwood/Hospital stations verified this, as the running Leq stabilized after only 2 minutes of measurements and varied by less than 1 dBA after 5 minutes, even during heavy truck pass-bys where 1-second Leq sound levels exceeded 92 dBA. Because of the constant traffic volumes on major highway like I-90, the short-term Leq experienced by patrons at the stations would be the same as the hourly Leq.

Rainier Station: Noise readings were taken at the proposed station location below the 23rd Avenue overpass. The 15 minute Leq was measured at 86.3 dBA Leq. Five receivers were modeled along the proposed platform, with two at each ends and one in the middle. The modeled noise levels ranged from 84.6 to 85.3 dBA Leq, which verified the accuracy of the model against the noise reading but also exceeded the 78 dBA goal for platform noise.

Ten-foot sound walls were modeled on the outside of the light rail station, along the edge the I-90 mainlines. With the walls in place, the noise levels along the platform were reduced by 8.2 to 9.7 dBA. Table 24 provides a summary of the noise model results along five points (receivers R1 through R5) of the station platform with and without the sound walls.

TABLE 24
Rainier Station Noise Analysis

Receiver No.	Measured Levels	Modeled Levels	Modeled Levels W/ Noise Walls	Noise Wall Reduction	Wall Details
R1	N/A	85.3	76.4	8.9	10 foot walls along the outside of the tracks, between the rail alignment and the I-90 traffic lanes. Walls could be integrated with the crash barriers to save room.
R2	N/A	85.1	76.9	8.2	
R3	N/A	85.0	75.8	9.2	
R4	N/A	84.9	75.2	9.7	
R5	86.3	84.6	75.4	9.2	

With noise walls the platform would have noise levels below the 78 dBA noise levels. The walls are proposed to extend approximately 800 feet west of the Mt. Baker Tunnel portals. Actual sound wall design would be performed during project final design.

Mercer Island Station: Noise readings were taken at the proposed station location below the 77th Avenue SE overpass. Two receivers located along the platform (Receivers R2 and R3) were modeled, and the modeled noise at both locations was 88 dBA Leq (Table 25).

TABLE 25
Mercer Island Station Noise Analysis

Receiver No.	Measured Levels	Modeled Levels[a]	Modeled Levels with Noise Walls	Noise Wall Reduction	Wall Details
R2	N/A	87.9	77.6	10.3	10-foot walls along the outside of the tracks, with the base of the wall at the same elevation as the tracks.
R3	N/A	87.9	78.3	9.6	

[a] The 87-dBA Leq is an average of the two measurement sessions.

By adding 10-foot sound walls on the outside of the light rail route along the edge nearest the train tracks, physically blocking the traffic noise on both sides of I-90 (see Appendix F for more information), the modeled noise levels along the platform were reduced by 10 dBA at the center of the platform. Table 25 provides a summary of the noise modeling results with and without the sound walls.

Ashwood/Hospital Station: Noise modeling was performed using projected 2030 traffic data and speeds for I-405. For patrons on the station platforms, noise levels would range from 75 to 78 dBA Leq. The lower noise levels on the platform would be due to the noise-reducing effects of the light rail route and bridge over I-405. Because the noise levels at the platform are projected to remain below 78 dBA Leq, no noise-reducing design improvements were investigated.

6.2 Light Rail Vibration and Ground-Borne Noise Impact Assessment

The approach used for assessing vibration impact uses many of the same inputs as the noise impact assessment, such as speed, frequency of vehicle events, and distance from the receiver to the tracks. The vibration impact assessment combines vehicle characteristics with soil propagation properties to estimate vibration levels at sensitive receptors. The FTA impact threshold for residential (Category 2) nighttime vibration is 72 VdB in each 1/3-octave band for a detailed vibration assessment. There are no Category 3 receptors identified with vibration impact along any of the proposed segments. The FTA impact threshold for residential ground-borne noise is 35 dBA. As stated in Chapter 3 of this report, ground-borne noise is only assessed for tunnel sections or for buildings that have sensitive interior spaces that are well-insulated from exterior noise.

For each East Link segment, a table is provided below that lists the locations, the distance to the nearest track, and the projected speed at each location. In addition, the predicted project vibration level or ground-borne noise level and the impact criterion level are indicated along with the number of impacts (single-family or multifamily buildings) projected for each receptor. The number of actual impacts in each building will be determined during preliminary engineering and design. All impacts described in this section are shown in Appendix A of this report, with individual maps for each alternative that would have noise and/or vibration impacts. In multistory buildings, vibration levels generally decrease as the vibration travels up through the building, and therefore impacts are not likely to be felt above the first few floors, depending on the type of building construction.

The impacts reported in this section are before mitigation and do not include mitigation measures for potential vibration and ground-borne noise levels and impacts reported in this section. Mitigation for potential impacts is discussed in Section 7.5.

6.2.1 Segment A

Table 26 provides the estimated vibration-velocity levels for sensitive receptors at representative distances. No vibration impacts were identified in Segment A. Table 27 shows the estimated ground-borne noise levels for sensitive receptors. The project vibration or ground-borne noise level listed is the

maximum for that location. In many cases, the vibration or ground-borne noise levels for other receptors would be much lower than the reported value.

The following section provides a brief description of the Category 2 land use area impacted by ground-borne noise, identified in Table 26.

Martin Luther King Junior Way S to Lake Washington: These 25 single-family residences are located above the I-90 Mt. Baker Tunnel. There are 25 buildings with projected ground-borne noise impact. Ground-borne noise impacts are projected at this location due efficient propagation of high-frequency vibration. However, the impact assessment at this location is based on a surface propagation test above the tunnel. During further engineering and design of the project, propagation testing should be conducted in the Mt. Baker Tunnel to determine if the propagation of ground-borne noise from the tunnel would occur as projected.

TABLE 26
Segment A Vibration Impacts

Location	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
12th Avenue to 23rd Avenue S	288	55	56	40	72	0
23rd Avenue S to Martin Luther King Jr Way S	134	55	61	40	72	0
Martin Luther King Jr Way S to Lake Washington	146	55	66	40	72	0
Mercer Island to W Mercer Way	160	50	57	12.5	72	0
W Mercer Way to 76th Avenue SE	202	50	56	12.5	72	0
76th Avenue SE to SE Shorewood Drive	187	55	59	12.5	72	0
SE Shorewood Drive to Lake Washington	179	55	60	12.5	72	0
Total						**0**

Notes:

Vibration levels are measured in VdB referenced to 1 micro inch/second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

All reported distances are slant distances from the top of rail for tunnel sections.

TABLE 27
Segment A Ground-Borne Noise Impacts

Location	Distance To Near Track (feet)	Speed (mph)	Max Ground-Borne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
Martin Luther King Jr Way S to Lake Washington	146	55	41	35	25 SF
Total					**25 SF**

Notes:

The reported ground-borne noise level represents the maximum level for each location.

All reported distances are slant distances from the top of rail for tunnel sections.

SF = single family

6.2.2 Segment B

Table 28 provides the estimated vibration velocity levels and impacts in Segment B for sensitive receptors at representative distances. The table identifies a vibration impact at one Category 2 building for the Bellevue Way Alternative (B1), as described below. No ground-borne noise impacts were identified because there are no tunnels in this segment.:

Bellevue Way SE and 112th Avenue to SE 10th Street: There is one single-family residence at this location that is projected to have vibration impact. The impact would be due to the proximity of the residence and the efficient propagation of vibration through the soil at this location.

No vibration impacts were identified for the remaining Segment B alternatives.

TABLE 28
Segment B Vibration Impacts

Alternative	Location	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
B1, Bellevue Way	Beginning of Segment B to Bellevue Way SE	165	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride Lot	103	55	67	12.5	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Ave	31	35	66	63	72	0
	Bellevue Way SE and 112th Ave to SE 10th Street	46	35	73	80	72	1 SF
	SE 10th St to End of Segment B (SE 6th Street)	50	35	71	80	72	0
B2A, 112th SE At-Grade	Beginning of Segment B to Bellevue Way SE	164	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride Lot	117	30	43	20	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Ave	41	35	59	50	72	0
	Bellevue Way SE and 112th Ave to SE 8th Street	76	35	64	80	72	0
	SE 8th Street to End of Segment B (6th Street SE)	59	20	69	80	72	0
B2E, 112th SE Elevated	Beginning of Segment B to Bellevue Way SE	164	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride Lot	174	55	45	12.5	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Ave	20	55	70	63	72	0
	Bellevue Way SE and 112th Ave to SE 8th Street	119	55	51	63	72	0
	SE 8th St to End of Segment B	102	55	53	63	72	0

TABLE 28
Segment B Vibration Impacts

Alternative	Location	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	(6th Street SE)						
B3, 112th SE Bypass	Beginning of Segment B to Bellevue Way SE	164	50	57	12.5	72	0
	Bellevue Way SE to South Bellevue Park-and-Ride Lot	193	55	49	12.5	72	0
	South Bellevue Park-and-Ride Lot to Bellevue Way SE and 112th Ave	41	35	59	50	72	0
	Bellevue Way SE and 112th Ave to SE 8th Street	80	35	63	80	72	0
	SE 8th St to End of Segment B (6th Street SE)	166	25	43	50	72	0
B7, BNSF	Beginning of Segment B to Mercer Slough	164	50	57	12.5	72	0
	Mercer Slough to SE 32nd Street/Henry Bock Road	231	55	43	12.5	72	0
	SE 32nd Street/Henry Bock Road to 118th Street crossing/118th Station	35	55	67	63	72	0

Notes:

Vibration levels are measured in VdB referenced to 1 μin/sec.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

6.2.3 Segment C

Table 29 shows the estimated vibration velocity levels for sensitive receptors at representative distances in Segment C. However, for highly sensitive locations, such as hospital and theater locations, additional analyses were required. This analysis follows the standard vibration analysis located in subsection 6.2.3.7.

A brief description of each impacted Category 2 land use area is provided by alternative below.

6.2.3.1 Bellevue Way Tunnel Alternative (C1T)

Impacts from this alternative would be due to the proximity of the alternative and to the speed of the light rail vehicles. One additional impact is recorded under Sub-section 6.2.3.7 for the highly sensitive location at Meydenbauer Center.

Beginning of Segment C to Main Street: There is one single-family residences at this location projected to have vibration impact and one with a ground-borne noise impact.

I-405 to NE 8th Street: Vibration impacts are projected at the Coast Bellevue Hotel.

6.2.3.2 106th NE Tunnel Alternative (C2T)

Impacts from this alternative would be due to the proximity of the alternative and to the speed of the light rail vehicles. There would be no vibration or ground-borne noise impacts from the connector to the 112th SE At-Grade Alternative (B2A).

Beginning of Segment C to Main Street (Connecting to the 112th SE Bypass [B3] and BNSF [B7] alternatives): A vibration impact for this alternative is projected at the Hilton Hotel. Additional testing will need to be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce the projected vibration levels. In addition, a survey of the building needs to be performed to determine the specific locations of vibration-sensitive uses within the structure. One additional impact is recorded under Sub-section 6.2.3.7 for the highly sensitive location at Meydenbauer Center.

Main Street to 106th Avenue NE (Connecting to the 112th SE Elevated Alternative [B2E]): Ground-borne noise impact is projected at one single-family residence on the south side of Main Street at this location.

6.2.3.3 108th NE Tunnel Alternative (C3T)

Impacts from this alternative would be due to the proximity of the alternative and to the speed of the light rail vehicles.

Beginning of Segment C to Main Street (Connecting to the 112th SE Bypass [B3] and BNSF [B7] alternatives): A vibration impact for this alternative is projected at the Hilton Hotel. Additional testing will need to be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce the projected vibration levels. In addition, a survey of the building needs to be performed to determine the specific locations of vibration-sensitive uses within the structure.

Begin C to 108th Avenue NE (Connecting to the 112th SE At-Grade Alternative [B2A]): Ground-borne noise impact is projected at two single-family residences just south of 110th Avenue SE at this location.

108th Avenue NE to Main Street (Connecting to B2A): Ground-borne noise impact is projected at nine single-family residences along NE 108th Avenue at this location.

NE 12th Street to 110th Avenue NE: Ground-borne noise impact is projected at one single-family residences north of NE 12th Street for all four connectors.

112th and Main Street to 108th Avenue NE (Connecting to the 112th SE Elevated Alternative [B2E]): Ground-borne noise impact is projected at one single-family residence on the south side of Main Street at this location.

6.2.3.4 Couplet Alternative (C4A)

Impacts from this alternative would be due to the proximity of the alternative to the buildings along its route.

NE 8th Street to NE 10th Street: Vibration impact is projected at two multifamily buildings along the northbound couplet at this location for all connections to Segment B.

NE 10th Street to 110th Avenue NE and NE 12th Street: Vibration impact is projected at two multifamily residences along the northbound couplet at this location for all connections to Segment B.

NE 12th St to 110th Ave NE: Vibration impact is projected at one single-family residence along the northbound couplet for all four alternatives. The impact is due to the very close proximity of the alignment.

Beginning of Segment C to 112th Avenue NE and Main Street (Connecting to the 112th SE Bypass Alternatives [B3] and to the BNSF Alternative [B7]): A vibration impact is projected at the Hilton Hotel for both alternative connections. The speed of light rail vehicles would also cause the impact. Additional

testing will need to be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce projected vibration levels. In addition, a survey of the building needs to be performed to determine the specific locations of vibration-sensitive uses within the structure. The connector portion south of Main Street for B2A and B2E do not result in any vibration impacts.**108th Avenue NE to NE 2nd Street:** Vibration impact is projected at two multifamily residences along the southbound couplet at this location for all connections to Segment B.

6.2.3.5 112th NE Elevated Alternative (C7E)

The impacts from this alternative would be due to the proximity of the alternative to the hotel and to the speed of the light rail vehicles.

Begin C to 112th Avenue NE and Main Street (Connecting to B3 and B7): A vibration impact is projected at the Hilton Hotel. Additional testing will need to be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce the projected vibration levels. In addition, a survey of the building needs to be performed to determine the specific locations of vibration-sensitive uses within the structure. The connector portion south of Main Street for B2A and B2E do not result in any vibration impacts.

6.2.3.6 110th NE Elevated Alternative (C8E)

The impacts from this alternative would be due to the proximity of the alternative to the hotel and to the speed of the light rail vehicles.

Beginning of Segment C to 112th Avenue NE and Main Street: A vibration impact is projected at the Hilton Hotel. Additional testing would need to be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce the projected vibration levels. In addition, a survey of the building needs to be performed to determine the specific locations of vibration-sensitive uses within the structure.

Main Street to 2nd Street between 114th Avenue NE and 112th Avenue NE: A vibration impact is projected at the Sheraton Hotel. Additional testing would need to be performed at this location to determine the response of the building foundation; the results of this testing would likely reduce the projected vibration levels. In addition, a survey of the building needs to be performed to determine the specific locations of vibration-sensitive uses within the structure.

NE 2nd Street between 110th Avenue NE and 112th Avenue NE to NE 4th Street: Vibration impact is projected at one multifamily residence at this location.

NE 8th Street to NE 10th Street: A vibration impact is projected at one multi-family residence at this location.

NE 10th Street to NE 12th Street: A vibration impact is projected at one multi-family residence at this location.

NE 12th Street to 112th Avenue NE: A vibration impact is projected at one single-family residence to the north of NE 12th Street at this location.

112th Avenue NE to the end of Segment C: A vibration impact is projected at one single-family residence to the north of NE 12th Street at this location.

TABLE 29
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
C1T, Bellevue Way Tunnel	Beginning of Segment C to Main Street		46	35	73	80	72	1 SF
	Main Street to Bellevue Way & NE 6th Street		105	55	48	10	72	0
	I-405 to NE 8th Street		26	55	75	80	72	1 Hotel
	NE 8th Street to End of Segment C		161	20	53	63	72	0
C2T, 106th NE Tunnel	Beginning of Segment C to Main Street	B2A, 11th SE At-Grade	86	55	48	8	72	0
		B2E, 112th SE Elevated	48	55	65	63	72	0
		B3, 112th SE Bypass B7, BNSF	15	55	84	80	72	1 Hotel
	Main Street to 106th Ave NE	B2A, 11th SE At-Grade	162	55	48	10	72	0
		B2E, 112th SE Elevated	56	55	62	63	72	0
		B3, 112th SE Bypass B7, BNSF	52	55	50	80	72	0
	I-405 to NE 8th Street	All	26	30	71	80	72	0
	NE 8th St to End of Segment C	All	161	20	53	63	72	0
C3T, 108th NE Tunnel	Beginning of Segment C to 108th Ave NE	B2A, 11th SE At-Grade	80	55	49	63	72	0
	108th Ave NE to Main Street		57	55	49	80	72	0
	Main Street to 6th Street/Bellevue Transit Center		88	55	48	10	72	0
	Beginning of Segment C to 112th & Main Street	B2E, 112th SE Elevated	48	55	65	63	72	0
		B3, 112th SE Bypass B7, BNSF	15	30	81	80	72	1 Hotel
	112th & Main Street to 108th Ave NE	B2E, 112th SE Elevated	138	55	59	63	72	0
		B3, 112th SE Bypass	202	55	48	10	72	0
		B7, BNSF	85	55	48	63	72	0

TABLE 29
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	108th Ave NE to NE 4th Street	B2E, 112th SE Elevated	109	55	48	10	72	0
		B3, 112th SE Bypass B7, BNSF	148	55	48	10	72	0
	6th Street/Bellevue Transit Center to NE 10th Street	All	92	55	48	10	72	0
	NE 10th St to NE 12th Street	All	101	55	48	10	72	0
	NE 12th Street to 110th Ave NE	All	39	55	53	40	72	0
	110th Ave NE to 112th Ave NE	All	85	55	66	63	72	0
	112th Ave NE to I-405/Ashwood Hospital Station	All	31	20	70	80	72	0
	I-405/Ashwood Hospital Station to End of Segment C (116th Ave NE)	All	257	20	38	50	72	0
C4A, Couplet	Beginning of Segment C to 112th & Main Street (eastbound)	B2E, 112th SE Elevated	76	20	55	63	72	0
	Base connect to NE 2nd Street (eastbound)	All	159	20	43	63	72	0
	NE 2nd Street to NE 4th Street (eastbound)	All	44	20	69	80	72	0
	NE 8th Street to NE 10th (eastbound)	All	32	20	73	80	72	2 MF
	NE 10th to 110th Ave NE & NE 12th Street (eastbound)	All	34	20	72	80	72	2 MF
	Eastbound/westbound matchline to 112th Ave NE (eastbound)	All	106	20	49	63	72	0
	I-405/Hospital Station to End of Segment C (eastbound)	All	182	20	33	31.5	72	0
	Beginning of Segment C to 112th Ave SE & Main Street (westbound)	B2A, 112th SE At-Grade B2E, 112th SE Elevated	51	55	61	80	72	0
		B3, 112th SE Bypass B7, BNSF	15	25	83	80	72	1 (Hotel)

TABLE 29
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	112th Ave SE & Main Street to Beginning of Segment C (westbound)	B2A, 112th SE At-Grade B2E, 112th SE Elevated	89	20	52	63	72	0
		B3, 112th SE Bypass B7, BNSF	94	20	51	63	72	0
	Begin Westbound Segment C to 108TH Ave NE (westbound)	All	82	20	63	63	72	0
	108th Ave NE to NE 2nd Street (westbound)	All	24	20	85	80	72	2 MF
	NE 2nd Street to NE 4th Street (westbound)	All	61	20	68	80	72	0
	NE 8th St to NE 10th St (WB)	All	51	20	71	80	72	0
	NE 10th St to NE 12th Street (westbound)	All	52	20	71	80	72	0
	NE 12th Street to 110th Ave NE (westbound)	All	27	20	83	80	72	1 SF
	110th Ave NE to Eastbound/Westbound matchline (westbound)	All	95	20	61	63	72	0
	Eastbound/Westbound matchline to 112th Ave NE (westbound)	All	31	20	70	80	72	0
	112th Ave NE to I-405/Hospital Station (westbound)	All	278	20	37	50	72	0
C7E, 112th NE Elevated	Beginning of Segment C to 112th Ave NE & Main Street	B2A, 112th SE At-Grade B2E, 112th SE Elevated	70	55	59	63	72	0
		B3, 112th SE Bypass B7, BNSF	15	20	83	80	72	1 (Hotel)
	112th Ave NE & Main Street to Base connect	All	113	55	52	63	72	0
	Base connect to NE 2nd Street		89	55	55	63	72	0
	NE 2nd Street to NE 4th Street		74	45	54	63	72	0
	NE 10th Street to NE 12th Street		76	55	58	63	72	0

TABLE 29
Segment C Vibration Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
	NE 12th Street to End of Segment C		152	20	44	63	72	0
C8E, 110th NE Elevated	Beginning of Segment C to 112th Ave NE & Main Street	All	26	55	75	80	72	1 (Hotel)
	112th Ave NE & Main Street to Base connect		41	55	67	63	72	0
	Main Street connect to 2nd Street between 110th and 112th		2*	55	100*	160	72	1 (Hotel)
	2nd Street between 110th and 112th to NE 4th Street		30	55	72	80	72	1 MF
	NE 4th St to NE 6th Street		51	55	64	63	72	0
	NE 8th St to NE 10th Street		29	55	73	80	72	1 MF
	NE 10th St to NE 12th Street		11	55	90	80	72	1 MF
	NE 12th Street to 112th Ave NE		21	20	77	80	72	1 SF
	112th Ave NE to End of Segment C		16	55	83	80	72	1 SF

Notes:‘

Vibration levels are measured in VdB referenced to 1 micro inch/second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted. All reported distances are slant distances from the top of rail for tunnel sections.

Base connect = point between Main Street and NE 2nd

SF = single family

MF = multifamily

* The vibration impact at this location will need to be reevaluated with further refinement of the alignment. Vibration projections are not accurate at this distance.

TABLE 30
Segment C Ground-Borne Noise Impacts (Does Not Include Highly Sensitive Locations)

Alternative	Location	Connector	Distance to Near Track (feet)	Speed (mph)	Max Ground-Borne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
C1T, Bellevue Way Tunnel	Beginning of Segment C to Main Street	N/A	59	35	35	35	1 SF
	Main Street to Bellevue Way & NE 6th Street		105	55	32	35	0
C2T, 106th NE Tunnel	Beginning of Segment C to 106th Street	All	78	35	34	35	0
	106th Street to Main Street	B2A, 112th SE At-Grade	162	55	29	35	0
		B2E, 112th SE Elevated	62	55	35	35	1 SF
		B3, 112th SE Bypass B7, BNSF	100	55	33	35	0
C3T, 108th NE Tunnel	Beginning of Segment C to 108th Ave NE	B2A, 112th SE At-Grade	71	35	36	35	2 SF
	108th Ave NE to Main Street		57	55	36	35	9 SF
	Main Street to 6th Street/Bellevue Transit Center		88	55	34	35	0
	Beginning of Segment C to 112th & Main Street	B3, 112th SE Bypass B7, BNSF	104	55	30	35	0
	112th & Main Street to 108th Ave NE	B2E, 112th SE Elevated	60	55	36	35	1 SF
		B3, 112th SE Bypass	79	55	33	35	0
		B7, BNSF	85	55	34	35	0
	108th Ave NE to NE 4th Street	B2E, 112th SE Elevated	109	55	32	35	0
		B3, 112th SE Bypass B7, BNSF	118	20	30	35	0
	6th Street/Bellevue Transit Center to NE 10th Street	All	92	55	33	35	0
	NE 10th Street to NE 12th Street	All	101	55	32	35	0
	NE 12th Street to 110th Ave NE	All	40	30	39	35	1 SF

Notes:
SF = single family

6.2.3.7 Highly Sensitive Locations Analysis

In addition to sensitive residential land uses, vibration and ground-borne noise impacts were assessed for other sensitive locations, including the Bellevue Arts Museum, the theater at Meydenbauer Center, and the Overlake Hospital MRI and Optical Surgery Unit. For the purposes of this assessment, the museum was treated as an auditorium because quiet is important to the use of a museum (see Table 10). In addition, ground-borne noise was also assessed for the Bellevue Arts Museum and the theater at Meydenbauer Center. Hospital equipment is not sensitive to ground-borne noise. The MRI and optical surgery unit impact levels are based on the criteria for highly sensitive sites (see Section 4.3, Transit Vibration and Ground-Borne Noise Criteria). The potential for vibration impacts to the new Group Health Bellevue Medical Center was evaluated, but all alternatives would be located at a great enough distance to prevent impacts to sensitive equipment within the facility.

The results in Tables 31 and 32 identify the vibration and ground-borne noise impacts, respectively, at the theater at Meydenbauer Center for the Bellevue Way Tunnel (C1T) and 106th NE Tunnel (C2T) alternatives (all connectors). An impact would only occur at the Meydenbauer Center and would be due to the proximity of the tunnel alternative to the Meydenbauer Center and to the speed of the light rail vehicles.

TABLE 31
Segment C Vibration Impacts for Highly Sensitive Locations

Location	Alternative	Distance To Near Track (feet)	Speed (mph)	Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
Bellevue Arts Museum	C1T, Bellevue Way Tunnel	65	20	51	N/A	72	0
Meydenbauer Center Theater	C1T, Bellevue Way Tunnel C2T, 106th NE Tunnel	50	45	75	N/A	72	1
Overlake Hospital MRI	C3T, 108th NE Tunnel C4A, Couplet C7E, 112th NE Elevated C8E, 110th NE Elevated	196	20	33	31.5	60	0
Overlake Hospital Optical Surgery Unit	C3T, 108th NE Tunnel C4A, Couplet C7E, 112th NE Elevated C8E, 110th NE Elevated	208	20	33	31.5	54	0

Notes:
Vibration levels are measured in VdB referenced to 1 micro inch/second.
The reported vibration level represents the maximum vibration level for each location.
The maximum vibration level reported is for the 1/3-octave band noted.

TABLE 32
Segment C Ground-Borne Noise Impacts for Highly Sensitive Locations

Location	Alternative	Distance To Near Track (feet)	Speed (mph)	Ground-Borne Noise Level (dBA)	Impact Criterion (dBA)	No. of Impacts
Bellevue Arts Museum	C1T, Bellevue Way Tunnel	65	20	34	35	0
Meydenbauer Center	C1T, Bellevue Way Tunnel C2T, 106th NE Tunnel	50	45	53	35	1

Notes:

The reported ground-borne noise level represents the maximum level for each location.

6.2.4 Segment D

Table 33 provides the estimated vibration velocity levels for sensitive receptors at representative distances in Segment D. An additional analysis of the potential for vibration impacts on the newly planned Children's Hospital was conducted and the results are provided in Table 34. No impacts were identified from the Segment D alternatives.

TABLE 33
Segment D Vibration Impacts

Alternative	Location	Connector	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3-Octave Band	Vibration Impact Criterion	No. of Impacts
D2A, NE 16th At-Grade	Beginning of Segment D to BNSF line Route Split	BNSF	203	55	53	25	72	0
		NE 12th	83	50	56	31.5	72	0
	Overlake Village Station to Overlake Transit Center Station	All	270	35	53	25	72	0
D2E, NE 16th Elevated	Beginning of Segment D to BNSF line Route Split	BNSF	203	35	55	25	72	0
		NE 12th	83	55	51	40	72	0
	Overlake Village Station to Overlake Transit Center Station	All	270	35	53	25	72	0
D3, NE 20th	Beginning of Segment D to BNSF line Route Split	BNSF	203	55	53	25	72	0
		NE 12th	83	45	55	31.5	72	0
	136th Place NE and NE 20th Street to 140th Avenue NE	All	158	35	57	25	72	0
	148th Avenue NE to 152nd Avenue NE	All	40	20	65	40	72	0
	152nd Avenue NE to NE 24th Street	All	182	35	56	25	72	0
	NE 24th Street to SR 520	All	219	35	55	25	72	0

TABLE 33
Segment D Vibration Impacts

Alternative	Location	Connector	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3- Octave Band	Vibration Impact Criterion	No. of Impacts
D5, SR 520	Beginning of Segment D to BNSF line Route Split	BNSF	145	55	55	25	72	0
		NE 12th	125	55	56	25	72	0
	124th Avenue NE to 130th Avenue NE	All	33	50	66	31.5	72	0
	NE 24th Street and 152nd Avenue NE to SR 520	All	234	35	54	25	72	0

Notes:
Vibration levels are measured in VdB referenced to 1 micro inch/second.
The reported vibration level represents the maximum vibration level for each location.
The maximum vibration level reported is for the 1/3-octave band noted.

TABLE 34
Segment D Vibration Impacts for Highly Sensitive Locations

Location	Alternative	Distance To Near Track (feet)	Speed (mph)	Vibration Level	1/3- Octave Band	Vibration Impact Criterion	No. of Impacts
Proposed Children's Hospital A.S.C.	D2A, NE 16th At-Grade D2E, NE 16th Elevated D3, NE 20th D5, SR 520	100	35	55	N/A	60	0

Notes:
Vibration levels are measured in VdB referenced to 1 micro inch/second.
The reported vibration level represents the maximum vibration level for each location.
The maximum vibration level reported is for the 1/3-octave band noted.

6.2.5 Segment E

Table 35 provides the estimated vibration velocity levels for sensitive receptors at representative distances in Segment E. A brief description of each impacted Category 2 land use area is provided by alternative below.

6.2.5.1 Redmond Way Alternative (E1)

The impacts from this alternative would be due to the speed of the light rail vehicles.

NE 51st Street to NE 60th Street: There is one single-family residence at this location with vibration impact projected. The building is located just to the south of NE 60th Street.

NE 60th Street to West Lake Sammamish Parkway: There would be impacts on two single-family residences in the residential community at this location, just before the alternative crosses SR 520.

6.2.5.2 Marymoor Alternative (E2)

The impacts from this alternative would be due to the speed of the light rail vehicles.

NE 51st Street to NE 60th Street: There is one single-family residence at this location, just to the south of NE 60th Street, with a projected vibration impact.

NE 60th Street to West Lake Sammamish Parkway: Vibration impacts are projected at two single-family residences located in the residential community just before the alternative crosses SR 520.

6.2.5.3 Leary Way Alternative (E4)

The impacts from this alternative would be due to the proximity of the alternative to the hotel and to the speed of the light rail vehicles.

NE 51st Street to NE 60th Street: There is one single-family residence at this location where vibration impact is projected. The building is located just to the south of NE 60th Street.

NE Leary Way to NE 76th Street: There are two projected impacts at this location. One impact would be at the hotel at the Redmond Town Center, which is within 5 feet of the alternative. The other impact would be on the south side of NE Leary Way where a multifamily building is located within 20 feet of the proposed alternative.

TABLE 35
Segment E Vibration Impacts

Alternative	Location	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3- Octave Band	Vibration Impact Criterion	No. of Impacts
E1, Redmond Way	NE 51st Street to NE 60th Street	37	55	77	63	72	1 SF
	NE 60th Street to West Lake Sammamish Parkway	31	55	80	40	72	2 SF
	West Lake Sammamish Parkway to 154th Avenue NE	21	25	65	63	72	0
	154th Avenue NE to BNSF corridor	286	25	30	20	72	0
	BNSF corridor to Leary Way	252	55	48	12.5	72	0
	Leary Way to 166th Avenue NE	73	55	56	63	72	0
	SR 520 to NE 70th Street	76	20	42	63	72	0
E2, Marymoor	NE 51st Street to NE 60th Street	37	55	77	63	72	1 SF
	NE 60th Street to West Lake Sammamish Parkway	28	55	82	40	72	2 SF
	166th Avenue NE to Leary Way	78	55	54	63	72	0
	Leary Way to 162nd Avenue NE	73	55	56	63	72	0
E4, Leary Way	NE 51st St to NE 60th Street	37	55	77	63	72	1 SF
	NE 60th Street to West Lake Sammamish Parkway	57	55	72	63	72	0

TABLE 35
Segment E Vibration Impacts

Alternative	Location	Distance To Near Track (feet)	Speed (mph)	Max Vibration Level	1/3- Octave Band	Vibration Impact Criterion	No. of Impacts
	West Lake Sammamish Parkway to NE Leary Way	209	25	31	20	72	0
	NE Leary Way to NE 76th Street	5	55	96	63	72	1 MF 1 hotel
	SR5 20 to NE 70th Street	76	20	52	63	72	0

Notes:

Vibration levels are measured in VdB referenced to 1 micro inch/second.

The reported vibration level represents the maximum vibration level for each location.

The maximum vibration level reported is for the 1/3-octave band noted.

MF = multifamily

SF = single family

6.2.6 Maintenance Facility Alternatives

No vibration impacts are projected to occur from operation and maintenance activities.

6.3 Construction Noise Assessment

Several construction phases would be required to complete the East Link Project. The analysis assumes the worst-case noise levels based on three major types of construction described below and shown in Table 36. The actual noise levels experienced during construction would generally be lower than those given in this report. The noise levels presented here are for periods of maximum construction activity and would occur for a limited period of time.

TABLE 36
Noise Levels for Typical Construction Phases[a]

Scenario[b]	Equipment[c]	Lm[d]	Leq[e]
Preparation and Utilities Relocation	Air compressors, backhoe, concrete pumps, crane, excavator, forklifts, haul trucks, loader, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment	94	87
Construction of Structures, Track Installation, and Paving	Air compressors, backhoe, cement mixers, concrete pumps, crane, forklifts, haul trucks, loader, pavers, pumps, power plants, service trucks, tractor trailers, utility trucks, vibratory equipment, welders	94	88
Miscellaneous activities	Air compressors, backhoe, crane, forklifts, haul trucks, loader, pumps, service trucks, tractor trailers, utility trucks, welders	91	83

[a] Combined worst-case noise levels for all equipment at a distance of 50 feet from work site.

[b] Operational conditions under which the noise levels are projected.

[c] Normal equipment in operation under the given scenario.

[d] Lm (dBA) is an average maximum noise emission for the construction equipment under the given scenario. For this type of equipment and activities, the Lm is approximately equal to the L01.

[e] Leq (dBA) is an energy average noise emission for construction equipment operating under the given scenario. For this type of equipment, the Leq is approximately equal to the L50.

6.3.1 Demolition, Site Preparation, and Utilities Relocation

Major noise-producing equipment used during the preparation stage could include saw cutters, concrete pumps, cranes, excavator, haul trucks, loader, tractor-trailers, and vibratory equipment. Maximum noise levels could reach 82 to 86 dBA at the nearest residences (i.e., within 50 to 100 feet) for normal construction activities during this phase. Other, less notable noise-producing equipment expected during this phase includes backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

6.3.2 Construction of Structures, Track Installation, and Paving

The loudest noise sources in use during construction of elevated structures would include cement mixers, concrete pumps, cranes, pavers, haul trucks, and tractor-trailers. The cement mixers, cranes and concrete pumps would be required for construction of the light rail superstructure. The pavers and haul trucks would be used to provide the final surface on the roadway. Maximum noise levels would range from 82 to 94 dBA at the closest receiver locations.

6.3.3 Miscellaneous Activities

Following the heavy construction, general construction such as installation of bridge railing, signage, roadway striping, communication and power systems, and other general activities would still need to occur. These less intensive activities are not expected to produce noise levels above 80 dBA at 50 feet except during rare occasions, and even then only for short periods of time. Using the information in Table 36, typical construction noise levels were projected for several distances from the project work area. Exhibit 22 is a graph of general construction noise level versus distance for project phases of construction.

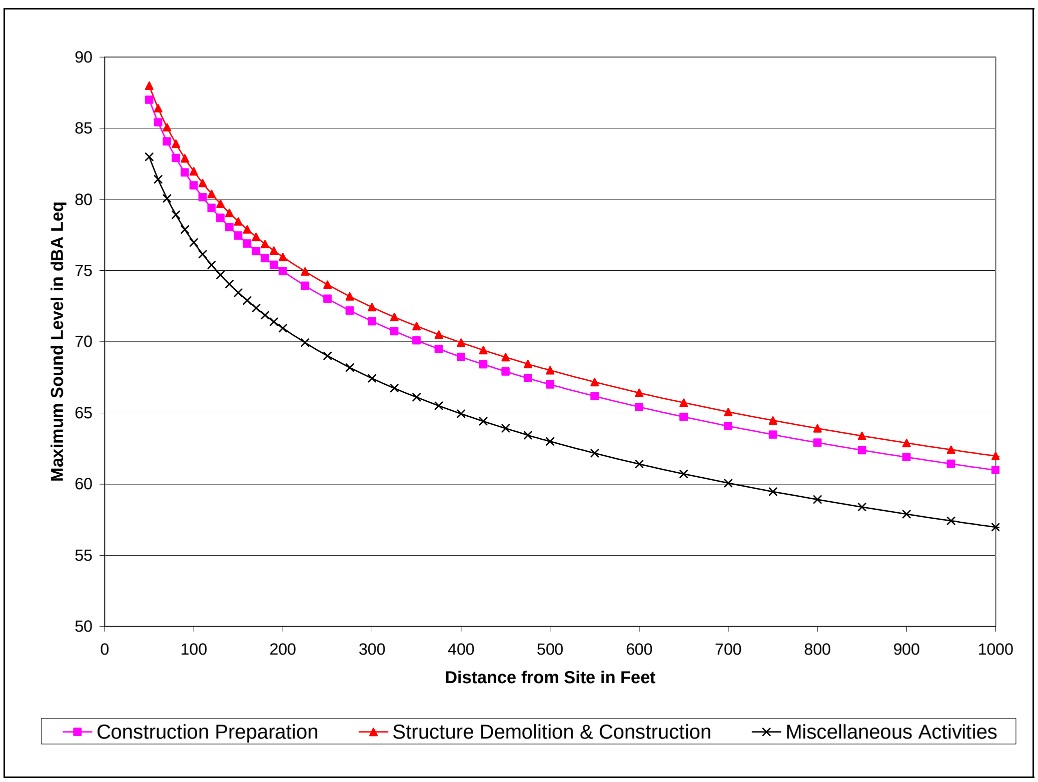


EXHIBIT 22
Maximum Noise Level Versus Distance for Typical Construction Phases

6.3.4 Pile Driving

Pile driving would likely be required to support permanent structures such as piers for elevated structures and cut-and-cover tunnel walls. Pile driving can produce maximum short-term noise levels of 99 to 105 dBA at 50 feet. Actual levels can vary and would depend on the distance and topographical conditions between the pile-driving location and the receiver location. Exhibit 23 is a graph of maximum pile driving noise levels versus distance.

6.3.5 Nighttime Construction Activities

It may be necessary to perform some construction activities during nighttime hours because of the nature of the construction or in order to avoid daytime traffic impacts or impacts to some adjacent land uses. In order to perform construction at night, a noise variance from the local governing agency would be required. Once a final alternative is selected, Sound Transit would work with the local governments and agencies to provide a construction plan that would allow the project to be constructed cost-effectively with minimal disruption to local areas and traffic flow. If nighttime construction is deemed necessary, Sound Transit would work with each governing agency to obtain any necessary noise variance specific to project construction.

6.3.6 Segment A Construction Noise

Because much of the light rail alternative in Segment A would be in commercial and industrial areas or in the I-90 highway corridor, many noise-sensitive areas would be shielded from much of the construction noise sources. Construction in the I-90 corridor, west of the Mount Baker Tunnel, would result in increased noise levels at the residential areas along Sturgus Avenue S and south of I-90 near the tunnel portal. Maximum noise levels from construction at these homes should not exceed 75 to 78 dBA under any phase of construction.

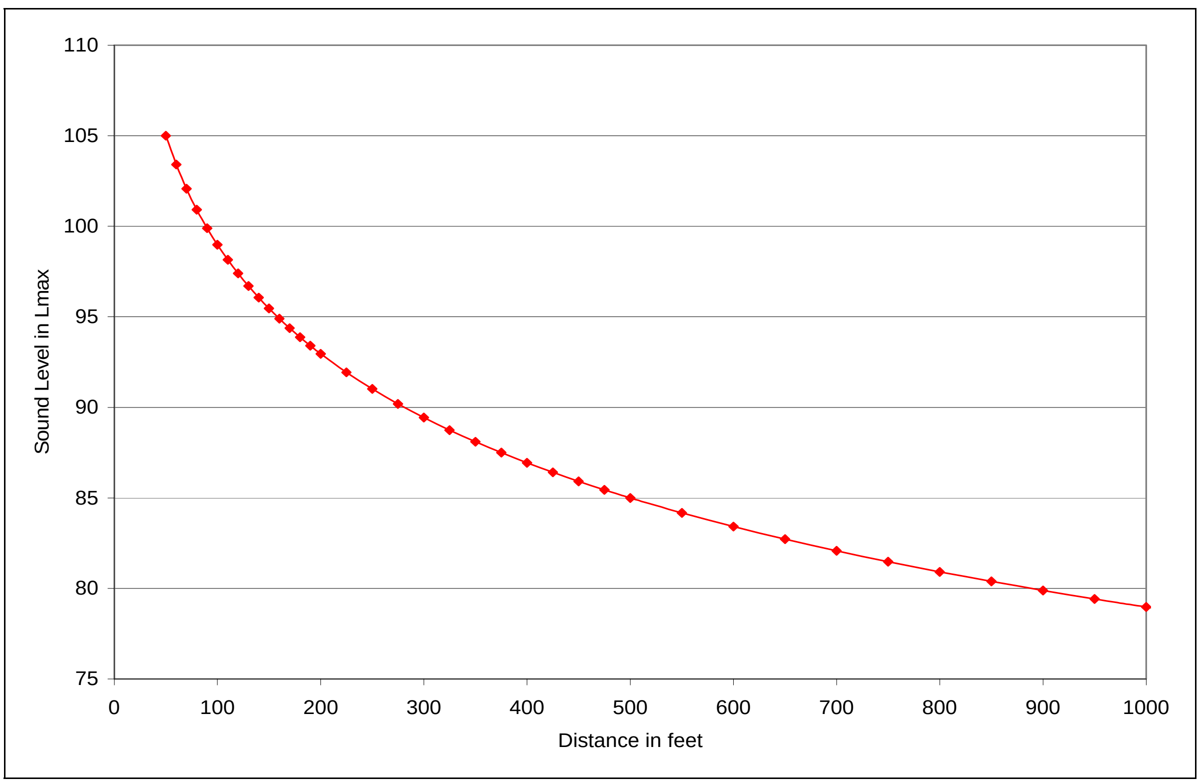


EXHIBIT 23
Pile Driving Noise Level Versus Distance

Maximum construction noise levels at residential locations on the east end of the Mount Baker Tunnel, near 35th Avenue S, are projected to reach up to 85 dBA Lmax during brief periods of heavy construction. Typical construction noise during daytime hours would be approximately the same as the existing traffic noise levels in this area.

On Mercer Island, most of the light rail alternative would be in a deep, retained cut with I-90, and the construction sites would be well shielded from noise-sensitive land uses. Residences located near the connection to the floating structure and the bridge to Bellevue would likely notice an increase in noise from construction activities for short periods of time. There would also be construction activities for the station platforms and access; however, station construction would likely be during daytime hours and would meet the local noise ordinance.

6.3.7 Segment B Construction Noise

There are a large number of single-family and multifamily residences along the Segment B alternatives. Under the Bellevue Way alternatives (i.e., Bellevue Way [B1], 112th SE At-Grade [B2A], 112th SE Elevated [B2E], and 112th SE Bypass [B3]), noise levels at adjacent residences would have short periods of time with maximum noise levels exceeding 80 dBA Lmax. Major construction noise would occur during utilities relocation, installation of retaining walls (where required), repaving Bellevue Way, and construction of the B2E and B3 elevated structures. There is also a potential for pile driving and sheet-pile installation. Pile driving could produce Lmax noise levels of 105 dBA at 50 feet. Although there would be periods of relatively loud construction, noise levels would decrease as tasks are completed and construction activities move to other areas.

Under B1, the impacts and noise levels described above would continue to the tunnel portal in Segment C. B2A, B2E, and B3 would be located on 112th Avenue SE, where residences in some areas are set back farther from the construction sites than they are on Bellevue Way. Therefore, noise levels on 112th Avenue SE would have a lower impact. The highest noise levels would occur during utilities relocation, repaving, and construction of the B2E and B3 elevated structures.

Under the BNSF Alternative (B7), noise levels at the multifamily apartments and condominiums adjacent to the alternative in the BNSF corridor could reach 80 dBA Lmax for short periods. Because this alternative would not be on a major roadway, it would be less likely that nighttime work would be required near the noise-sensitive units. Pile driving may also be required under this alternative along the I-90 corridor to SE 32nd Street. Noise from the pile driver could exceed 85 dBA Lmax at the nearby multi-family residences south of SE 32nd Street. The pile driving would also increase noise levels in the southern section of the Mercer Slough Nature Park. Worst-case noise levels of up to 100 dBA Lmax can be expected within 100 feet of the construction site, as shown on Exhibit 23.

There are also several commercial structures that would be affected by construction noise in Segment B. Businesses located along Bellevue Way would have short periods of time with maximum noise levels exceeding 80 dBA Lmax under B1. The business parks located south of 112th Avenue SE would also experience elevated noise levels under B2A, B2E, and B3. B7 would also increase noise at some commercial structures; however, traffic noise from I-405 would remain a significant noise source at commercial structures along this alternative.

6.3.8 Segment C Construction Noise

Construction in downtown areas is often difficult due to high traffic volumes and general congestion. Major noise sources would include haul truck traffic to and from tunnel-staging areas, pile driving for elevated structures, cement-pumping trucks, and cement delivery trucks. Major noise-producing activities would include utilities relocation, repaving project roadways, and construction of elevated structures. The projected construction noise levels are typical for transportation construction projects, such as roadway paving projects. The main differences between a typical paving operation and the tunnel construction are the length of time to complete the project and the level of haul truck activity.

Noise levels at residences near tunnel portals and staging areas on Bellevue Way could exceed 80 dBA Lmax during heavy construction periods for the Bellevue Way Tunnel Alternative (C1T). Typical daytime noise levels from the staging areas are projected to be 73 to 84 dBA, depending on the level and type of activity at the time. Maximum noise levels of over 80 dBA Lmax could still occur in locations where the homes are directly on 112th Avenue SE, such as for the single-family and multifamily homes between SE 6th Street and Main Street, for all alternatives except the C1T. Noise levels would also exceed 80 dBA Lmax along the residential area on 110th Avenue NE and at the single-family residences north of NE 12th Street for the 108th NE Tunnel (C3T), the Couplet (C4A) and the 110th NE Elevated (C8E) alternatives. Noise levels at the residential area on Lake Bellevue are not projected to exceed 80 dBA Lmax, except during pile driving, structure construction, or utilities relocations.

Noise levels near the tunnel portal and staging areas along Main Street are also predicted to range from 73 to 84 dBA Lmax at 50 feet from the site. Construction noise levels at residences in the Surrey Downs neighborhood would vary and depend on how close the residence is to the site and the level of shielding the residence has from existing homes. The highest levels would be at residences directly adjacent to the construction site. Similar construction noise levels are also projected for the tunnel portal and staging areas near McCormick Park under the 108th NE Tunnel (C3T), Couplet (C4A), and 110th NE Elevated (C8E) alternatives. Construction of the elevated structure under the 112th NE Elevated Alternative (C7E) would also result in construction noise at residential and commercial land uses along 112th Avenue NE.

C3T, C4A, C7E, and C8E would require construction along NE 12th Street near the Overlake Medical Center, the proposed Children's Hospital A.S.C. and nearby supporting offices. Maximum noise levels at the hospital are projected to reach up to 82 dBA Lmax, with typical noise levels ranging from 71 to 75 dBA. The parking structure at both hospitals is expected to act as a noise barrier and provide some noise reduction from construction activities.

Commercial land uses in Segment C would also experience elevated noise levels during construction. For the Bellevue Way Tunnel (C1T) and 106th NE Tunnel (C2T) alternatives, elevated noise levels would be experienced along the entire corridor due to cut-and-cover construction methods. For the 108th NE Tunnel Alternative (C3T), which would use bored tunneling construction methods, most construction-related noise would be at the portals and the Bellevue Transit Center Station. The Couplet Alternative (C4A) would require heavy at-grade construction along 108th Avenue NE and 110th Avenue NE, including utilities relocation, track installation, and paving. Maximum levels could exceed 80 dBA Lmax during periods of heavy construction. C7E and C8E are both elevated and would require installation of the elevated structure along 110th Avenue NE (C8E) or 112th Avenue NE (C7E), resulting in maximum levels of 80 to 85 dBA at 50 feet from the project work site.

6.3.9 Segment D Construction Noise

Segment D has a limited number of residential land use that would be affected by construction noise. There would be an increase in noise at the residential area on Lake Bellevue when connecting to the Bellevue Way Tunnel (C1T) and 106th NE Tunnel (C2T) alternatives. Construction noise would also affect the multifamily building on NE 21st Place, just south of SR 520, and the proposed Children's Hospital on 116th Avenue NE, if it is constructed prior to the project.

The Group Health Eastside Hospital Campus is currently being redeveloped to mixed residential commercial land use. Construction of the NE 16th At-Grade (D2A), NE 16th Elevated (D2E), and NE 20th (D3) alternatives would have the highest impact on the new mixed-use development planned for this site, due to the proximity of these alternatives. Maximum noise levels are projected to reach up to 82 dBA Lmax, with typical noise levels ranging from 69 to 78 dBA. Commercial and retail land uses along the proposed corridors would also experience maximum levels of 80 to 85 dBA at 50 feet from the project work site during periods of heavy construction.

6.3.10 Segment E Construction Noise

Removal and replacement of existing sound walls adjacent to SR 520 could be required from the beginning of Segment E to West Lake Sammamish Parkway. During wall replacement, noise levels at the residences would see an increase not only from construction noise but also from traffic noise on SR 520. During heavy periods of construction, noise levels could reach 85 dBA Lmax, with typical hourly average noise levels ranging from 70 to 80 dBA. Once the sound walls are replaced, work on the light rail construction would be mostly shielded by the walls, and noise levels should not exceed 60 to 70 dBA.

Construction of the elevated portion of the Leary Way Alternative (E4) near the Redmond Town Center would result in noise-level increases at the multifamily units along Leary Way. Maximum noise levels are projected to range from 80 to 85 dBA Lmax during the heaviest construction periods. Pile driving may also be required for the elevated structures, which could result in peak noise levels exceeding 100 dBA.

Construction of the at-grade portions of all alternatives through Downtown Redmond would increase noise levels during utilities relocations, paving, and track installation, with maximum noise levels of 80 to 85 dBA Lmax.

Construction noise levels in Marymoor Park are predicted to reach 80 to 85 dBA Lmax during heavy construction for the Marymoor Alternative (E2). Pile driving may be required for the Sammamish River crossing, which could result in peak noise levels exceeding 100 dBA.

6.3.11 Maintenance Facility and Park-and-Ride Lot Construction Noise

Except for the 116th Maintenance Facility (MF1), the maintenance facility alternatives are not near residential land uses that would be affected by construction noise. Some residences are present on the west side of 116th Avenue NE, near MF1. Construction of the maintenance bases and park-and-ride lots is projected to produce maximum noise levels of 75 to 85 dBA Lmax at 50 feet during periods of heavy construction. The loudest noise sources would include cement mixers, concrete pumps, cranes, and haul trucks. Cement mixers, cranes, and concrete pumps would be required for construction of multistory parking facilities and maintenance buildings. For surface lots and station construction, the loudest construction noise sources are pavers and haul trucks that would be used to apply the asphalt and construct access roads. Other, less notable noise-producing equipment includes backhoes, air compressors, forklifts, pumps, power plants, service trucks, and utility trucks.

6.4 Construction Vibration Assessment

Based on the damage criteria described in Section 4.5, the only activity likely to cause damage would be impact pile driving at locations within 25 feet of structures. However, there are many alternatives that would require impact pile driving, including sonic pile driving and push piling. The locations of where there would be piles will not be available until preliminary engineering, but they will likely include locations with elevated structures or retained cuts approaching tunnels. As specific locations of piles are developed, more analysis should be conducted. To prevent damage, care should be taken to avoid pile driving too close to buildings.

To assess the potential for temporary, short-term construction vibration impacts, construction vibration levels were predicted for tunnel construction operations in Segment C and for piling and vibratory rolling along the entire corridor. Reference vibration levels have been collected from other environmental vibration studies. Data for tunnel-boring machines include tunneling in rock and in soil. However, based on the geotechnical investigations to date, the East Link project would not require tunneling in rock. Table 37 shows the reference vibration levels for these sources at 25 feet.

TABLE 37
Vibration Levels for Construction Equipment

Construction Equipment	Maximum Lv at 25 feet (VdB)
Tunnel-Boring Machine (in rock)	85
Tunnel-Boring Machine (in soil)	69
Muck trains	72
Vibratory Roller	94
Impact Pile Driving	112

Vibration levels are predicted on the ground floors inside buildings. This assumes no coupling attenuation (i.e., reduction in vibration level due to the foundation) for single-family residences, a 10-dB building coupling attenuation for large masonry buildings, no floor-to-floor attenuation and no amplification due to the resonances of the floors. Table 38 shows the distances at which ground-borne vibration impacts would occur for single-family residences and large masonry buildings for each piece of construction equipment. These distances correspond to vibration in any 1/3-octave band between 8 and 80 Hz that exceeds the criterion.

The results of this analysis show that temporary, short-term vibration impact would not be an issue for tunnel construction. As discussed in Section 4.5, criteria levels for impacts to buildings range from 94 VdB for non-engineered timber and masonry buildings to 102 VdB for reinforced concrete, steel, or timber buildings. The maximum VdBs provided in Table 37 are at or below the lowest impact criteria level. The only likely source of construction vibration annoyance would be pile driving. If alternative methods of pile driving can be employed, the distance to vibration impact can be greatly reduced.

TABLE 38
Distances from Sources to Ground-Borne Vibration Impact

Construction Equipment	Distance to Ground-Borne Vibration Impact (feet)
Tunnel-Boring Machine in Rock (large masonry buildings)	17
Tunnel-Boring Machine in Rock (single-family residences)	36
Tunnel-Boring Machine in Soil (large masonry buildings)	6
Tunnel-Boring Machine in Soil (single-family residences)	13
Muck Trains (large masonry buildings)	8
Muck Trains (single-family residences)	16
Vibratory Roller (large masonry buildings)	18
Vibratory Roller (single-family residences)	36
Impact Pile Driving (large masonry buildings)	70
Impact Pile Driving (single-family residences)	150

Table 39 shows the range of distances from various sources to the threshold for ground-borne noise impact for both single-family residences and large masonry buildings. The ground-borne noise impact criterion is 40 dBA, based on frequent events for Category 3 land uses (see Table 9 in Section4.3). These

results show that there is the possibility of ground-borne noise impact from muck train activities; however, this would depend on the depth of the tunnel at any particular location. It is important to note that these are temporary impacts, and the annoyance from these activities would be limited in duration. For most activities, including tunneling, the duration would be a few days for each activity. The only activity with a longer duration would be use of muck trains near the portals of the tunnels, which could be required for between 1 month and 18 months, depending on the tunnel alternative chosen and the speed of tunneling.

TABLE 39
Distances from Sources to Ground-Borne Noise Impact

Construction Equipment	Distance to Ground-Borne Noise Impact (feet)
Tunnel-Boring Machine in Soil (large masonry buildings)	7
Tunnel-Boring Machine in Soil (single-family residences)	14
Muck Trains (large masonry buildings)	24
Muck Trains (single-family residences)	51

7.0 Potential Mitigation of Noise and Vibration Impacts

Sound Transit has developed and adopted a noise and vibration mitigation policy. This policy, approved in 2004, was designed to provide guidance on the analysis and mitigation of noise impact associated with Link light rail projects. The following policies shall guide Sound Transit's assessment and control of potential Link noise impacts.

A. Sound Transit shall comply with applicable federal, state, and local noise requirements in evaluating noise impacts, determining appropriate mitigation measures, and implementing Link projects.

B. Sound Transit will seek to identify potential noise impacts and potential mitigation measures early in the project development process, as practicable.

C. Sound Transit will seek to reduce expected noise impacts, as practicable, through reductions in source emissions and project design.

D. Sound Transit will seek to work with local jurisdictions to provide that development that occurs is compatible with expected or existing project operational noise.

7.1 Potential Light Rail Noise Mitigation Options

One of the most effective forms of noise mitigation is to attempt to reduce noise at the source. Source noise reduction is normally accomplished through vehicle specifications. Sound Transit has purchased state-of-the-art, low-noise vehicles equipped with noise-reducing wheel skirts covering the wheel-rail interface. There are also several additional operational measures that can reduce noise levels at the source. Table 40 provides a list of operational and maintenance measures that Sound Transit would perform on a regular basis and the benefit that each of the measures would provide.

TABLE 40
System-Wide Light Rail Operational Mitigation

Operational Measure	System Benefit
Rail Grinding and Replacement	As rails wear, both noise and vibration levels from light rail operations can increase. By grinding or replacing worn rails, noise and vibration levels will remain at the projected levels. Rail grinding or replacement is normally performed every 3 to 5 years.
Wheel Truing and Replacement	Wheel truing is a method of grinding down flat spots (commonly called "wheel flats") on the vehicle wheels. Flat spots occur primarily because of hard braking. When flat spots occur they can cause increases in both the noise and vibration levels produced by the light rail vehicles.
Vehicle Maintenance	Vehicle maintenance includes performing scheduled and general maintenance on items such as air conditioning units, bearings, wheel skirts, and other mechanical units on the light rail vehicles. Keeping the mechanical systems on the light rail vehicles in top condition will also help to maintain the projected levels of noise and vibration.
Operator Training	Operators will be trained to operate light rail vehicles at the speeds given in the operation plan that was used for the analysis and to avoid "hard-braking," which can cause wheel flats and may also damage the track. Furthermore, by training operators to identify potential wheel flats and other mechanical problems with the trains, proper maintenance can be performed in a more timely manner.

For locations where potential noise impacts have been identified, mitigation measures would be considered and reviewed using Sound Transit's Mitigation Policy. Under the Sound Transit Mitigation Policy, mitigation measures would be considered for all noise impacts. As described above, source treatments that Sound Transit is currently using to minimize noise impacts include requiring wheel skirts, maintaining smooth tracks, vehicle maintenance and wheel truing, and operator training.

For any residual noise impacts, the next type of mitigation considered would be applied between the noise source and receiver. Typical path mitigation includes sound walls, earth berms, and buffer zones. Construction of sound walls between the light rail tracks and the affected receivers would reduce noise levels by physically blocking the transmission of noise generated by light rail. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls and are usually constructed with a 3-to-1 slope. For the East Link Project, berms would not be feasible due to topographical conditions and limited right-of-way. For at-grade or elevated structures, sound walls should be high enough to break the line of sight between the noise source and the receiver. Typical height for at-grade sound walls is 6 to 8 feet and 4 to 6 feet when on elevated structures. Sound walls must also be long enough to prevent flanking of noise around the ends of the walls. Openings in noise walls for driveway connections or intersecting streets greatly reduce the effectiveness of barriers.

Buffer zones are undeveloped, open spaces between the noise source and receiver. Buffer zones are created when an agency purchases land or development rights in addition to the normal right-of-way, so that future dwellings cannot be constructed close to the noise source. This prevents the possibility of constructing dwellings that would otherwise experience an excessive noise levels. However, because the East Link Project is in an urban setting where land is at a premium, creating buffer zones is not a feasible form of noise mitigation.

For situations where path mitigation is either not feasible or ineffective, sound insulation would be considered. Sound insulation programs are developed to make sure that the interior noise levels in sleeping and living quarters in residential land uses or in noise-sensitive areas of schools and other institutional uses remain within the guidelines set by the Department of Housing and Urban Development (HUD). Under theses guidelines, noise levels in sensitive areas of residential land uses cannot exceed 45 dBA Ldn and some form of fresh air exchange must be maintained. The air exchange can be achieved by opening a window or using some form of ventilation system. Sound insulation is normally only used on older dwellings with single-pane windows, or in buildings with double-pane windows that are no longer effective due to leakage. Sound insulation would not reduce exterior noise levels.

Finally, when a light rail vehicle travels over a crossover, there is a loud clicking noise as the steel wheels go over the gap between the tracks. This can increase noise levels from the train by as much as 10 dBA compared to a smooth track with no gaps. Mitigation for noise impacts from crossover tracks can include relocating the crossover away from noise-sensitive properties, use of special frogs that include gap-closing mechanisms, or using movable point frogs. A "frog" is a rail-crossing structure at track crossovers, which allow the train to cross over to another track or continue moving on the same track. A gap is provided on top of the frog so that vehicle wheels can pass regardless of which track is in use. With standard rigid frogs, vibration occurs when the wheels pass over the gap, but a moveable point frog eliminates the gap and one end of the frog moves in the direction of train travel. Other similar options are spring-rail or flange-bearing frogs.

The FTA considers impacts in the severe category as those requiring the most thorough noise mitigation consideration if the project cannot avoid the impact. Sound Transit is committed to reducing or eliminating severe impacts. For impacts in the moderate category, the FTA provides more leeway regarding required mitigation, and several factors can be considered, such as the existing noise levels, existing and future land use, and the severity of the moderate impact. Finally, any proposed noise mitigation measure must be considered reasonable and feasible to be included with the project. Feasibility includes two main factors: the overall noise-reduction of the mitigation and its constructibility.

The reasonability criteria of noise mitigation are related to the cost and noise-reduction of the proposed mitigation. Other items that may be considered include community input, land use, whether the impact occurs on a ground floor or upper floor, and safety.

7.2 Potential Traffic Noise Mitigation Options

For locations with residual traffic-noise impacts caused by the East Link Project, Sound Transit may consider sound insulation. Use of FHWA or WSDOT funds for sound insulation of residences for traffic noise abatement is allowed only in specific situations. WSDOT and FHWA policies and procedures, and 23 CFR 772.13(c)(6), limit sound insulation for traffic-noise abatement to public use or nonprofit institutional structures and only in situations where a barrier is ineffective, unreasonable, and/or infeasible and interior noise levels are above the impact criteria. Sound insulation of residences is allowed only when noise impacts are severe (i.e., above 80 dBA exterior or above 60 dBA interior) and no other type of abatement is possible. In contrast, Sound Transit considers residential sound insulation for any noise impacts related to light rail projects if a barrier is ineffective, unreasonable, and/or infeasible, including impacts from traffic caused by road realignment or additional lanes constructed during light rail construction. The mitigation proposed follows Sound Transit policy.

Several different traffic-noise abatement measures are evaluated whenever noise impacts are expected. These include traffic management measures, highway design measures, and noise barriers such as earthen berms. Other mitigation measures, such as property acquisition, were not considered for the East Link Project. Specific mitigation measures recommended as part of the project must be feasible and reasonable. Possible mitigation measures are provided below.

7.2.1 Traffic Management Measures

Traffic management measures include modification of speed limits and restricting or prohibiting truck traffic. Restricting truck use on the project roadways would reduce noise levels at nearby receivers because trucks are louder than cars. However, displacing truck traffic from one roadway to another would only shift noise impacts from one area to another and conflict with the project objective.

7.2.2 Highway Design Measures

Highway design measures include altering the roadway alignment and depressing roadways in cut sections. Alteration of a roadway alignment could decrease noise levels by moving the noise source farther away from the affected receivers. Topographical and built-environment considerations determine the proposed project profile. There are no opportunities on the East Link Project for highway design options that could be used to provide noise mitigation.

7.2.3 Noise Barriers

Construction of noise barriers between the roadways and the affected receivers would reduce noise levels by physically blocking the transmission of traffic-generated noise. Barriers can be constructed as walls or earthen berms. Earthen berms require more right-of-way than walls and are usually constructed with a 3-to-1 slope. For the East Link Project, berms would not be feasible because of the right-of-way requirements.

Noise walls should be high enough to break the line-of-sight between the noise source and the receiver. They must also be long enough to prevent substantial flanking of noise around the ends of the walls. For a noise barrier to be considered feasible, most first-row receivers must have a minimum 5-dB insertion loss and at least one receiver must have a 7-dB reduction. Openings in the noise walls for driveways and walkways can considerably reduce the barrier effectiveness.

The relationship of the location of a noise barrier to the receptors to be protected would be considered in making a reasonableness determination. Very tall barriers located close to the receptors can have a negative visual impact.

7.3 Potential Noise Mitigation Measures

7.3.1 Segment A

There were no light rail noise impacts identified in Segment A, and therefore no noise mitigation is recommended in this segment.

7.3.2 Segment B

For the Bellevue Way Alternative (B1), noise impacts were identified at three residences along Bellevue Way due mainly to the location of a double crossover near SE 30th Street. Relocating the crossover to the south or using a spring or movable point crossover would reduce the noise impacts in this area. If crossover relocation is not an option, then the use of a special crossover or a noise wall in combination with residential sound insulation. Noise walls would not be effective north of SE 30th Avenue due to required openings for the intersection and for driveways.

The impacts of the BNSF Alternative (B7) on the multifamily units could be mitigated with at-grade sound walls, with any residual impacts mitigated with residential sound insulation. Table 41 provides a summary of the noise mitigation options for Segment B. With the mitigation measures, all light rail noise impacts in Segment B could be mitigated.

TABLE 41
Light Rail Noise Mitigation Measures for Segment B

Alternative	Moderate Impacts	Severe Impacts	Potential Noise Mitigation Measures	Residual Impacts
B1, Bellevue Way	0	3	Relocated crossover; spring flange crossover; sound insulation	0
B7, BNSF	11	36	Sound wall	0
	42	--	Sound wall	0
	6	3	Sound wall	0

The primary mitigation measures for traffic noise impacts under the Bellevue Way (B1), 112th SE At-Grade (B2A), and 112th SE Bypass (B3) alternatives would be sound walls. There are a large number of driveways along the northern section of Bellevue Way, and topographical conditions in the southern end of Bellevue Way where the residences are elevated above the roadway would reduce the overall effectiveness of sound walls. For locations where sound walls would be considered, they must be considered feasible and reasonable, as described above, to be recommended for inclusion with the project. Table 42 provides a summary of project-related traffic noise impacts and potential traffic noise mitigation measures.

7.3.2.1 Bellevue Way Alternative (B1)

There are 13 single-family residences that would exceed the FHWA/WSDOT noise criteria under B1. These 13 residences are located south of the station, in the vicinity of SE 30th Street and 112th Avenue SE and 113th Avenue SE. Receivers located at the intersection of Bellevue Way and SE 30th Street also would have light rail-related noise impacts due to a double crossover. Mitigation south of SE 30th Street could include a sound wall along the property line. North of SE 30th Street, driveways for local access would make a sound wall ineffective, and sound insulation would be used to provide traffic noise mitigation.

North of the South Bellevue Station, eight single-family homes would exceed the WSDOT criteria. In addition, seven single-family homes would exceed the WSDOT criteria near the intersection of 112th Avenue SE. Noise walls would be considered for feasibility and reasonability along the property line or

on retaining walls. If sound walls cannot meet the criteria, sound insulation could be used to mitigate the noise impacts.

Noise impacts at the apartments at the intersection of 112th Avenue SE and Bellevue Way could be mitigated with a sound wall on the retaining wall at the intersection. North of 108th Avenue NE, driveways and general vehicle and pedestrian access would reduce the overall effectiveness of sound walls. In addition, most of the impacts along the northern end of Bellevue Way would be to multifamily, multilevel units. Therefore, north of 108th Avenue NE, noise mitigation would likely be performed with sound insulation.

7.3.2.2 112th SE At-Grade (B2A) and Bypass (B3) Alternatives

For the 112th SE At-Grade (B2A) and Bypass (B3) alternatives, traffic-noise impacts would only occur between the transition from the South Bellevue Station to Bellevue Way and the intersection of 112th Avenue SE. Sound walls would be considered along the property line or on retaining walls for feasibility and reasonability; otherwise, sound insulation could be used to mitigate the noise impacts.

With the proposed mitigation, all noise impacts would be mitigated for both alternatives. It is important to note that for those locations with sound insulation, the exterior noise levels may still exceed the criteria. For most locations, such exterior locations would be on a balcony or side yard, and in a few circumstances, front yards. The actual change in noise levels at exterior locations would be typically 3 dBA or less, and at a few locations there would be 4 dBA increases. Because it takes a 3 dBA change in traffic noise for most humans to notice a difference, the exterior increases would be considered not noticeable in all but a few locations.

TABLE 42
Summary of Segment B Traffic Noise Impacts and Potential Mitigation Measures

Alternative	Traffic Noise Impacts	Potential Noise Mitigation Measure	Residual Impacts
B1, Bellevue Way	3 SF residences	Sound wall	0
	10 SF residences	Sound wall	0
	8 SF residences	Sound wall	0
	7 SF residences	Sound wall	0
	35 MF units 19 SF residences	Insulation	Exterior only-54 SF and MF units
B2A, 112th SE At-Grade, and B3, 112th SE Bypass	8 SF residences	Sound wall	0
	5 SF residences	Sound wall	0
	7 SF residences	Sound wall	0

SF = single-family

MF = multi-family

7.3.3 Segment C

The Bellevue Way Tunnel (C1T) and 106th NE Tunnel (C2T) alternatives both would result in light rail noise impacts on 12 multifamily residential units at Lake Bellevue, and these impacts could be mitigated with sound insulation or a sound wall on the elevated guideway.

Other light rail noise impacts in Segment C would be related to the crossovers on SE 112th Avenue near the connections to Segment B and near Main Street. Use of a spring flange crossover for the at-grade rail

sections would reduce impacts, and sound insulation could mitigate all noise impacts. All interior light rail noise impacts for the elevated alternatives could be mitigated with sound walls on the structures or sound insulation. With the recommended mitigation, all light rail noise impacts in Segments C would be mitigated. For multifamily residences where sound insulation would be used, noise levels may still exceed the criteria on exterior balconies of the multifamily units. Most of these balconies, however, are not large enough for active use and are ornamental only.

There are several multifamily units that would have traffic-noise impacts due to roadway widening for the Bellevue Way Alternative (C1T). Because of property access requirements, noise walls would not be feasible. Sound insulation would be used to mitigate the traffic noise impacts for C1T. The proposed mitigation would mitigate all noise impacts, with some residual noise on balconies and decks along 110th Avenue NE.

Table 43 provides a summary of light rail impacts in Segment C and potential noise mitigation measures.

Table 44 provides a summary of traffic noise impacts in Segment C and potential noise mitigation measures

TABLE 43
Light Rail Noise Mitigation Measures for Segment C

Alternative	Moderate Impacts	Severe Impacts	Potential Noise Mitigation Measures	Residual Impacts
C1T, Bellevue Way Tunnel, and C2T, 106th NE Tunnel (all connectors)	12 MF	--	Sound wall	0
C2T, 106th NE Tunnel (connecting from B2E, 112th SE Elevated)	--	18 hotel rooms 6 SF units	Sound wall	0
C2T, 106th NE Tunnel (connecting from B3, 112th SE Bypass and B7,BNSF)	4 Hotel rooms	--	Insulation	0
C3T, 108th NE Tunnel (connecting from B2E, 112th SE Elevated)	--	18 hotel rooms 2 SF 4 MF	Sound wall	0
C3T, 108th NE Tunnel (connecting from B3, 112th SE Bypass and B7,BNSF)	4 Hotel rooms	--	Insulation	0
C4A, Couplet (connecting from B2A, 112th SE At-Grade)	12 MF	--	Insulation	exterior
C4A, Couplet (connecting from B2E, 112th SE Elevated)	--	6 MF	Sound wall	0
C4A, Couplet (connecting from B3, 112th SE Bypass and B7,BNSF)	4 Hotel rooms	--	Insulation	0
C7E, 112th NE Elevated (connecting from B2A, 112th SE At-Grade)	--	2 SF 10MF	Sound wall	0
C7E 112th NE Elevated (connecting from B2E, 112th SE Elevated)	--	2 SF 4 MF	Sound wall	0
C7E, 112th NE Elevated (connecting from B3, 112th SE Bypass and B7,BNSF)	4 Hotel rooms	--	Insulation	0
C8E, 110th NE Elevated	80 MF	--	Residential sound insulation	exterior
	4 Hotel Rooms	--	Insulation	0
	3 SF	--	Sound wall	0

SF = single-family

MF = multi-family

TABLE 44
Summary of Segment C Traffic Noise Impacts and Potential Mitigation Measures

Alternative	Traffic Noise Impacts	Potential Noise Mitigation Measure	Residual Impacts
C1T, Bellevue Way Tunnel	21 MF units	Insulation	Exterior only for 21 MF units

SF = single-family

MF = multi-family

7.3.4 Segment D

There were 10 moderate light rail noise impacts identified in Segment D. All the impacts are at an apartment building south of SR 520 and north of Northup Way on NE 21st Place. The impacts would be mitigated with a sound wall along the elevated structure. Table 45 provides the details on the noise mitigation.

TABLE 45
Light Rail Noise Mitigation Measures for Segment D

Alternative	Moderate Impacts	Severe Impacts	Potential Noise Mitigation Measures	Residual Impacts
D5, SR 520	10 MF	--	Sound wall	0

7.3.5 Segment E

Impacts in Segment E were identified at the multifamily units along 156th Place NE, above West Lake Sammamish Parkway. The recommended mitigation would be to install sound walls along the elevated guideways. With the recommended mitigation, all light rail noise impacts in Segment E would be mitigated. Table 46 summarizes light rail mitigation for Segment E. There were no traffic noise impacts identified in Segment E.

TABLE 46
Light Rail Noise Mitigation Measures for Segment E

Alternative	Moderate Impacts	Severe Impacts	Potential Noise Mitigation Measures	Residual Impacts
E1, Redmond Way	26 MF	--	Sound wall	0

7.4 Potential Light Rail Vibration Mitigation Options

This assessment assumes that the vehicle wheels and track would be maintained in good condition with regular wheel truing and rail grinding, per Sound Transit maintenance procedures. Beyond this, there are several approaches to reduce ground-borne vibration from light rail operation, described in the following subsections. In almost all cases, vibration mitigation is possible with either ballast mats or resilient rail fasteners. At some locations, however, the tracks are within less than 20 feet of buildings, and the vibration levels are too high for mitigation to be completely effective. At these locations, more analysis needs to be completed to determine if the tracks will be this close to individual buildings.

7.4.1 Ballast Mats

A ballast mat consists of a pad made of rubber or rubber-like material placed on an asphalt or concrete base with the normal ballast, ties, and rail on top. The reduction in ground-borne vibration provided by a ballast mat is strongly dependent on the vibration frequency content and the design and support of the mat.

7.4.2 Resilient Rail Fasteners

Resilient fasteners can be used to provide vibration isolation between rails and concrete slabs for direct fixation track on elevated structures or in tunnels. These fasteners include a soft, resilient element to provide greater vibration isolation than standard rail fasteners in the vertical direction. This type of mitigation can be used in tunnels instead of floating slabs, where appropriate.

7.4.3 Tire-Derived Aggregate

Also known as shredded tires, a typical Tire-Derived Aggregate (TDA) installation consists of an underlayment of 12 inches of nominally 3-inch-size tire shreds or chips wrapped with filter fabric, covered with 12 inches of sub-ballast and 12 inches of ballast above that to the base of the ties. This type of mitigation can only be used on ballast and tie track. Tests suggest that the vibration-attenuation properties of this treatment are midway between that of ballast mats and floating slab track. While this is a low-cost option, it has only recently been installed on two U.S. light rail transit systems—in San Jose and Denver—and its long-term performance is unknown.

7.4.4 Floating Slabs

Floating slabs consist of thick concrete slabs supported by resilient pads on a concrete foundation; the tracks are mounted on top of the floating slab. Although floating slabs are designed to provide vibration reduction at lower frequencies than ballast mats, they are extremely expensive and are rarely used, except in the most extreme situations. Most successful floating-slab installations are in subways, and their use for at-grade track is less common and often not reasonable.

7.4.5 Special Trackwork

Because the impacts of vehicle wheels over rail gaps at track turnout locations increases ground-borne vibration by about 10 VdB, turnouts are a major source of vibration impact when they are located in sensitive areas. If turnouts cannot be relocated away from sensitive areas, another approach is to use spring-rail, flange-bearing or moveable-point frogs in place of standard rigid frogs at turnouts. These devices allow the flangeway gap to remain closed in the main traffic direction for revenue service trains.

7.5 Potential Light Rail Vibration Mitigation Measures

Vibration and ground-borne noise impacts that exceed FTA criteria are considered to be significant and to warrant mitigation, if reasonable and feasible. In almost all cases, vibration mitigation is possible with either ballast mats or resilient rail fasteners. Table 47 lists the number of proposed light rail vibration and ground-borne noise impacts and the distances of contiguous locations along each alternative where mitigation measures are recommended.

For C2T. the 108th NE Tunnel (C3T) and the 112th NE Elevated (C7E) alternatives connecting from the 112th SE Bypass (B3) and BNSF (B7) alternatives; the only residual vibration impact would the Hilton Hotel. For the Couplet Alternative (C4A), residual vibration impacts would include the Hilton Hotel and two multifamily buildings on the southbound couplet track. For the 110th NE Elevated Alternative (C8E), residual vibration impacts would occur at the Sheraton Hotel and one multifamily building. Additional testing would need to be performed at these locations to determine the response of the building foundations to light rail vibration, which would likely reduce the projected vibration levels. In addition, a survey of the buildings needs to be performed to determine the specific locations of vibration sensitive uses within the structures to assess actual impacts.

No vibration impacts were projected for Segment D; therefore, no mitigation would be required.

TABLE 47
Vibration Mitigation Locations

Alternative	Connection	Length of Mitigation Locations (ft)	Before Mitigation		With Mitigation	
			# Vibration Impacts	# Ground-Borne Noise Impacts	# Vibration Impacts	# Ground-Borne Noise Impacts
Segment A						
A1	--	1,900	0	25 SF	0	0
Segment B						
B1, Bellevue Way	--	200	1 SF	0	0	0
Segment C						
C1T, Bellevue Way Tunnel	--	1,200	0	1 SF	0	0
		700	1 SF	0	0	0
		600	1 Hotel	0	0	0
C2T, 106th NE Tunnel	B2A, 112th SE At-Grade	700	0	1	0	0
	B2E, 112th SE Elevated	200	0	1 SF	0	0
		700	0	0	0	0
	B3, 112th SE Bypass B7, BNSF	700	1 Hotel	0	1 Hotel	0
		700	0	1	0	0
C3T, 108th NE Tunnel	B2A, 112th SE At-Grade	300	0	2 SF	0	0
		900	0	9 SF	0	0
		700	0	1 SF	0	0
	B2E, 112th SE Elevated	300	0	1 SF	0	0
		200	0	1 SF	0	0
	B3, 112th SE Bypass B7, BNSF	800	1 Hotel	0	1 Hotel	0
		200	0	1 SF	0	0
C4A, Couplet	B2A, 112th SE At-Grade B2E, 112th SE Elevated	400	4 MF	0	2 MF	0
		1,200	2 MF 1 SF	0	0	0
	B3, 112th SE Bypass B7, BNSF	800	1 Hotel	0	1 Hotel	0
		400	4 MF	0	2 MF	0
		1,200	2 MF 1 SF	0	0	0

TABLE 47
Vibration Mitigation Locations

Alternative	Connection	Length of Mitigation Locations (ft)	Before Mitigation		With Mitigation	
			# Vibration Impacts	# Ground-Borne Noise Impacts	# Vibration Impacts	# Ground-Borne Noise Impacts
C7E, 112th NE Elevated	B2A, 112th SE At-Grade B2E, 112th SE Elevated	None	0	0	0	0
	B3, 112th SE Bypass B7, BNSF	800	1 Hotel	0	1 Hotel	0
C8E, 110th NE Elevated	B3, 112th SE Bypass B7, BNSF	800	1 Hotel	0	0	0
		1,100	1 Hotel 1 MF	0	1 Hotel	0
		1,800	2 MF 2 SF	0	1 MF	0
Segment D	--	N/A	0	0	0	0
Segment E						
E1, Redmond Way	--	300	1 SF	0	0	0
		400	2 SF	0	1	0
E2, Marymoor	--	300	1 SF	0	0	0
		400	2 SF	0	1	0
E4, Leary Way	--	300	1 SF	0	0	0
		200	1 MF	0	0	0
		400	1 Hotel	0	0	0

SF = single-family

MF = multi-family

7.5.1 Potential Vibration Mitigation for Highly Sensitive Locations

The impact to the Meydenbauer Center from the Bellevue Way Tunnel (C1T) and the 106th NE Tunnel (C2T) alternatives could be mitigated through the installation of ballast mats or resilient rail fasteners. However, more extensive mitigation may be required to adequately reduce the vibration levels to below the FTA impact criteria.

7.6 Potential Construction Noise Mitigation Measures

Sound Transit has developed a Construction Noise Mitigation Policy. Under this policy, Sound Transit would seek to limit construction noise levels and impacts and meet applicable noise regulations and ordinances. Typical mitigation measures that could be applied are discussed below, and a specific construction noise analysis will be performed with the selection of the locally preferred alternative. Contractors would be required to meet the criteria in city noise ordinances.

Several noise-mitigation measures can be implemented to limit construction noise impacts. Sound Transit would, as practical, limit construction activities that produce the highest noise levels during daytime

hours, or when disturbance to sensitive receivers would be minimized. For operation of construction equipment that could exceed allowable noise limits during nighttime hours (between 10 p.m. and 7 a.m.) or on Sundays or legal holidays, Sound Transit would obtain the appropriate noise variance from the City of Seattle, the City of Mercer Island, the City of Bellevue, or the City or Redmond. Sound Transit would control nighttime construction noise levels by applying noise-level limits and noise-control measures where necessary. The contractor would have the flexibility of either prohibiting certain noise-generating activities during nighttime hours or providing additional noise-control measures to meet these noise limits. Noise-control mitigation may include the following measures, as necessary, to meet required noise limits:

- Construction site noise barrier wall by noise sensitive receivers
- During nighttime work use smart back-up alarms, which automatically adjust the alarm level based on the background level, or switch off back-up alarms and replace with spotters.
- Low-noise emission equipment
- Noise-deadening measures for truck loading and operations
- Monitoring and maintenance of equipment to meet noise limits
- Lined or covered storage bins, conveyors, and chutes with sound-deadening material
- Acoustic enclosures, shields or shrouds for equipment and facilities
- High-grade engine exhaust silencers and engine-casing sound insulation
- Prohibition of aboveground jack-hammering and impact pile driving during nighttime hours
- Minimization of the use of generators to power equipment
- Limited use of public address systems
- Grading of surface irregularities on construction sites
- Use of moveable noise barriers at the source of the construction activity
- Limitation or avoidance of certain noisy activities during nighttime hours

To mitigate noise related to pile driving, the use of an augur to install the piles instead of a pile driver would greatly reduce the noise levels. If pile driving is necessary, the only mitigation would be to limit the time of day the activity can occur. Pile driving is not expected at most construction locations.

7.6.1 Segment A Construction Noise Mitigation

Construction noise mitigation for Segment A would include the mitigation measures described above. No additional noise mitigation other than those provide should be required.

7.6.2 Segment B Construction Noise Mitigation

Construction noise mitigation for Segment B would include the mitigation measures described above. No additional noise mitigation other than those provide should be required.

7.6.3 Segment C Construction Noise Mitigation

Construction noise mitigation for Segment C would include the mitigation measures described above. Because of the staging areas and tunnel portals along Bellevue Way, 112th Avenue SE, Main Street, and NE 12th Street, construction of temporary noise barriers could be used near tunnel staging areas to reduce noise levels at nearby residential land uses in the Surrey Downs neighborhood and near McCormick Park.

7.6.4 Segment D Construction Noise Mitigation

Construction noise mitigation for Segment D would include the mitigation measures described above. No additional noise mitigation other than those provide should be required.

7.6.5 Segment E Construction Noise Mitigation

Construction noise mitigation for Segment E would include the mitigation measures described above. Construction of the route along SR 520 near 51st Street NE could result in the movement of existing noise walls; every attempt should be made to replace the wall early in the project to minimize impacts to nearby residents before track construction.

7.7 Potential Construction Vibration Mitigation Measures

Damage from construction vibration is limited to impact pile driving at very close distances to buildings. If piling can be more than 25 to 50 feet from buildings, or if alternative methods, such as push piling, can be used, damage from construction vibration should not be an issue. Other sources of construction vibration do not generate high enough vibration levels for damage to occur. In any locations of concern, pre-construction surveys should be conducted to document the existing condition of buildings, in case there is an issue during or after construction.

Mitigation measures for short-term or temporary annoyance from ground-borne vibration and ground-borne noise due to construction activities such as piling or vibratory rolling are limited to use of alternative construction methods, such as auger piling, push piling, or limiting the hours and duration of construction activities. Because the tunneling is likely to occur in soil and not rock, there should be no vibration- or ground-borne-noise-annoyance issues related to the tunnel boring machines or muck trains. To mitigate vibration related to pile driving, the use of an augur to install the piles instead of a pile driver would greatly reduce the vibration as well as noise levels. If pile driving is necessary, the only mitigation would be to limit the time of day the activity can occur. Pile driving is not expected at most construction locations. For most areas, vibration monitoring would be considered for all activities that may produce vibration levels at or above a PPV of 0.5 inches per second (500,000 micro-inches/second) whenever there are structures located near the construction activity. Activities with this potential impact include pile driving, vibratory sheet installation.

8.0 References

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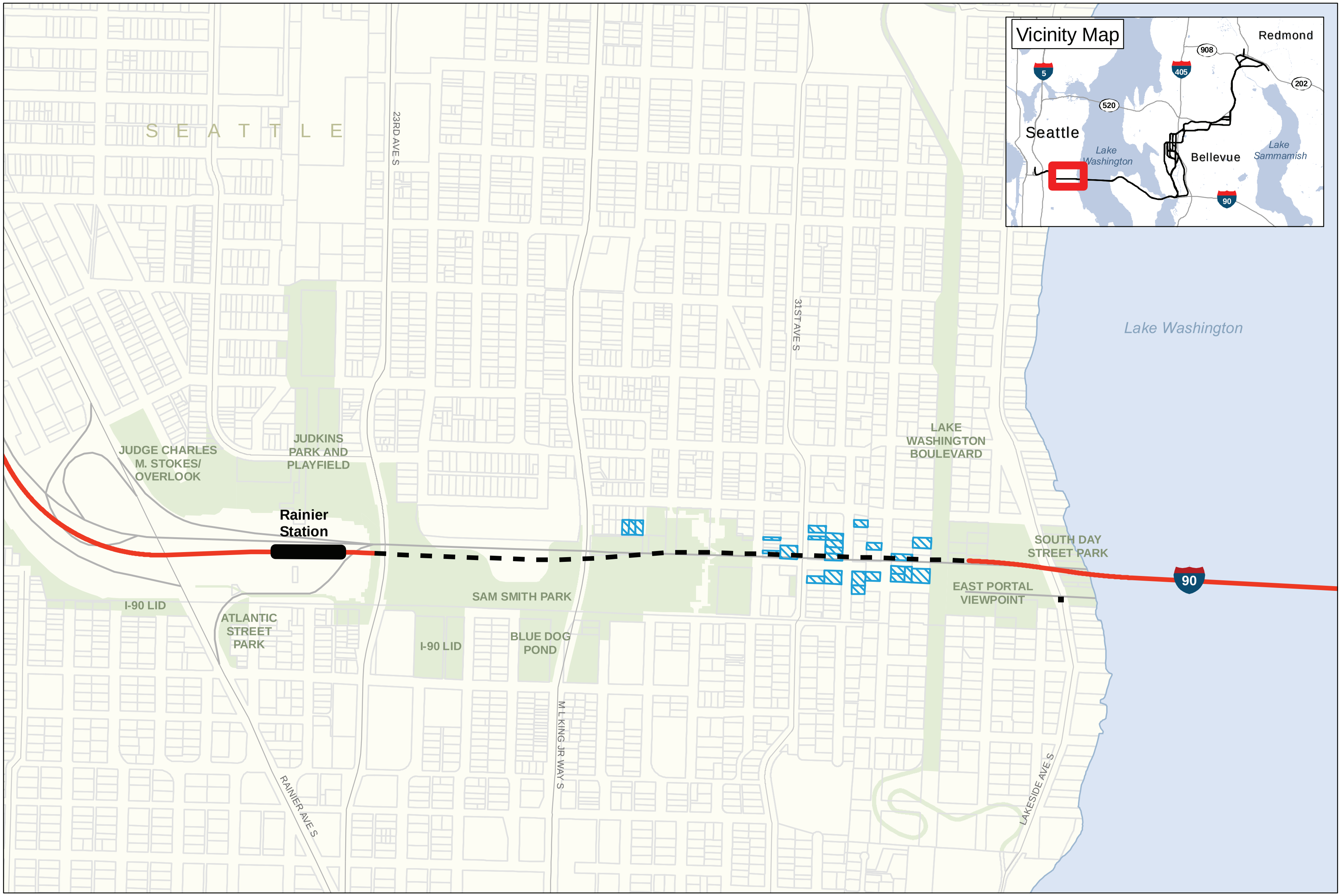
U.S. Environmental Protection Agency (EPA). 1974. *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA/ONAC 550/9-74-004.* March, 1974.

Appendix A

Noise and Vibration Impacts by Affected Alternative



Source: Data City of Seattle (2002), King County (2006), and Sound Transit (2007).

A1 SDE.Parcels2007

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route

Traction Power Substation
Proposed Station

N

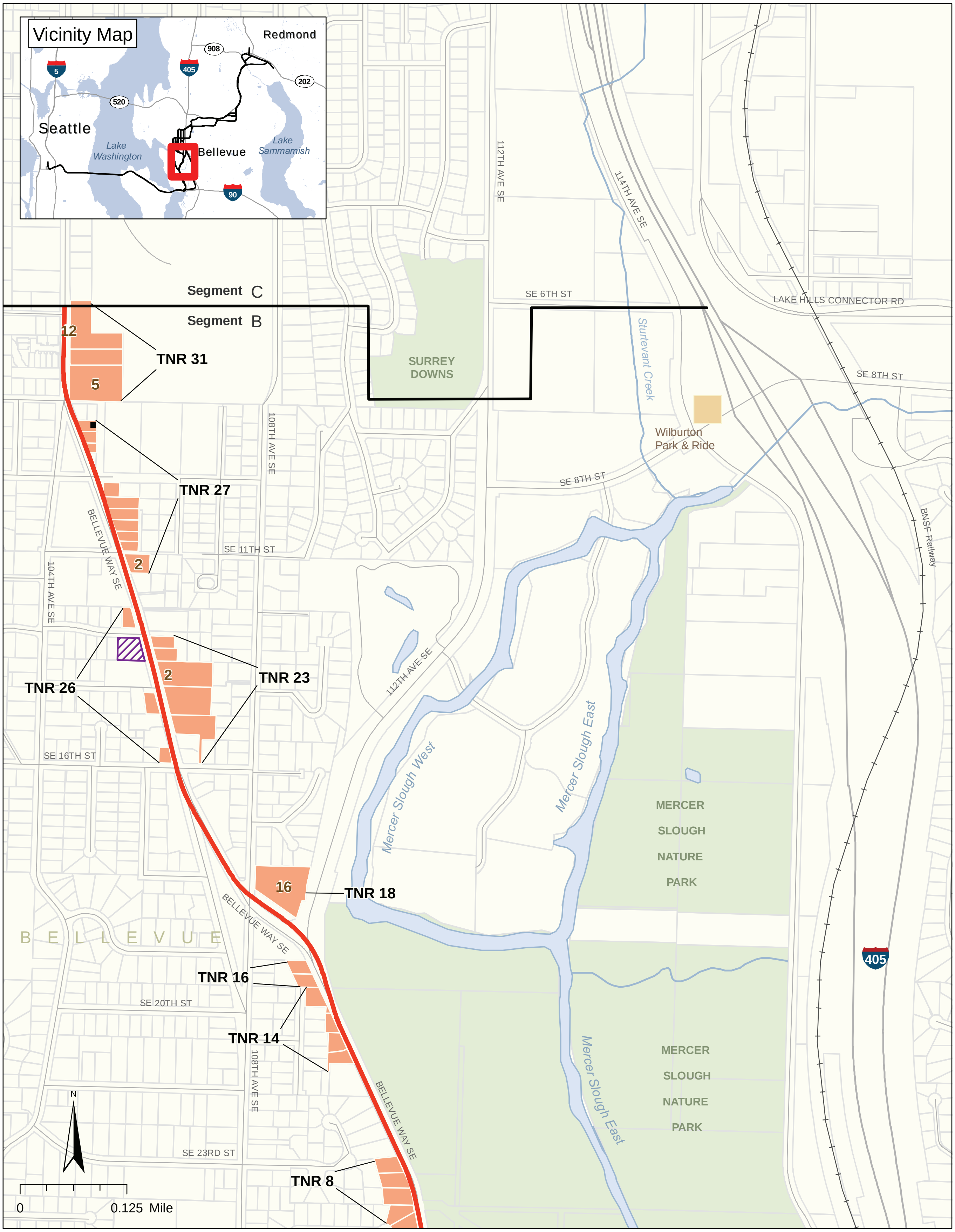
0 0.1 0.2 Miles

Exhibit A-1 **Potential Noise and Vibration Affected Parcels Segment A, Alternative A1**
East Link Project

Source: Data from CH2M HILL (2007) and King County (2006).

Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
Light Rail & Traffic Noise Affected Parcel
26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

Exhibit A-2 **Potential Noise and Vibration Affected Parcels Segment B, Alternative B1**
East Link Project



Vibration Affected Parcel

Traffic Noise Affected Parcel

26 Number of Impacted Noise Receivers

TNR 1 Traffic Noise Modeling Receiver Number

At-Grade Route

Elevated Route

Retained-Cut Route

Tunnel Route

Proposed Station

Traction Power Substation

Source: Data from CH2M HILL (2007) and King County (2006).

NOTE:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Exhibit A-3 **Potential Noise and Vibration Affected Parcels Segment B, Alternative B1**
East Link Project

Source: Data from CH2M HILL (2007) and King County (2006).

Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
Light Rail & Traffic Noise Affected Parcel
26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

Exhibit A-4 **Potential Noise and Vibration Affected Parcels Segment B, Alternative B2A**
East Link Project

Source: Data from CH2M HILL (2007) and King County (2006).

Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
Light Rail & Traffic Noise Affected Parcel
26 Number of Impacted Noise Receivers

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number

Proposed Station
Traction Power Substation

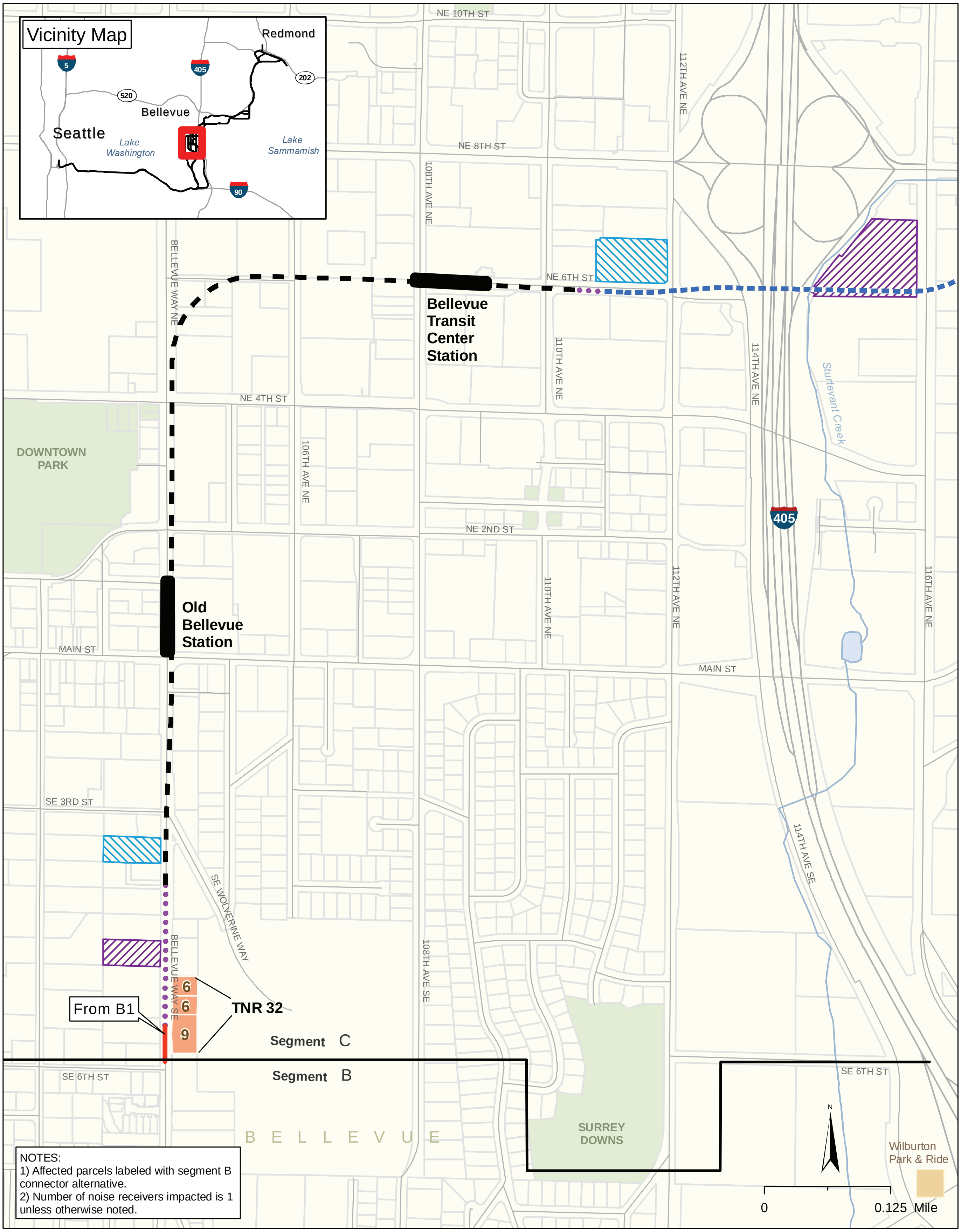
Exhibit A-5 **Potential Noise and Vibration Affected Parcels Segment B, Alternative B3**
East Link Project

NOTE:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Source: Data from CH2M HILL (2007) and King County (2006).

Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
Light Rail & Traffic Noise Affected Parcel
26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

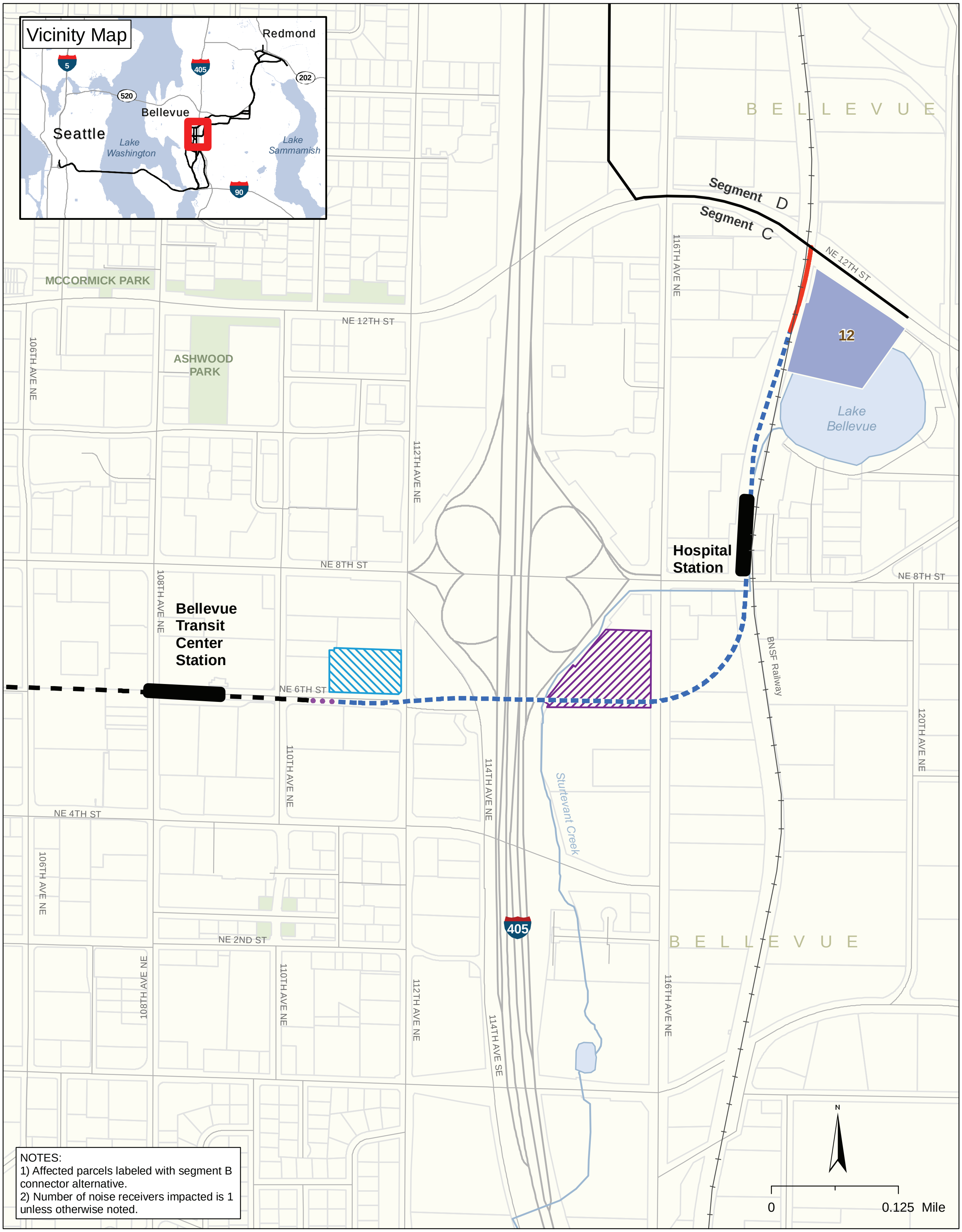
Exhibit A-6 **Potential Noise and Vibration Affected Parcels Segment B, Alternative B7**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

- Vibration Affected Parcel
- Ground Borne Noise Affected Parcel
- Light Rail Noise Affected Parcel
- Traffic Noise Affected Parcel
- R Residual Vibration Impact
- 26 Number of Impacted Noise Receivers
- At-Grade Route
- Elevated Route
- Retained-Cut Route
- Tunnel Route
- TNR 1 Traffic Noise Modeling Receiver Number
- Proposed Station
- Traction Power Substation

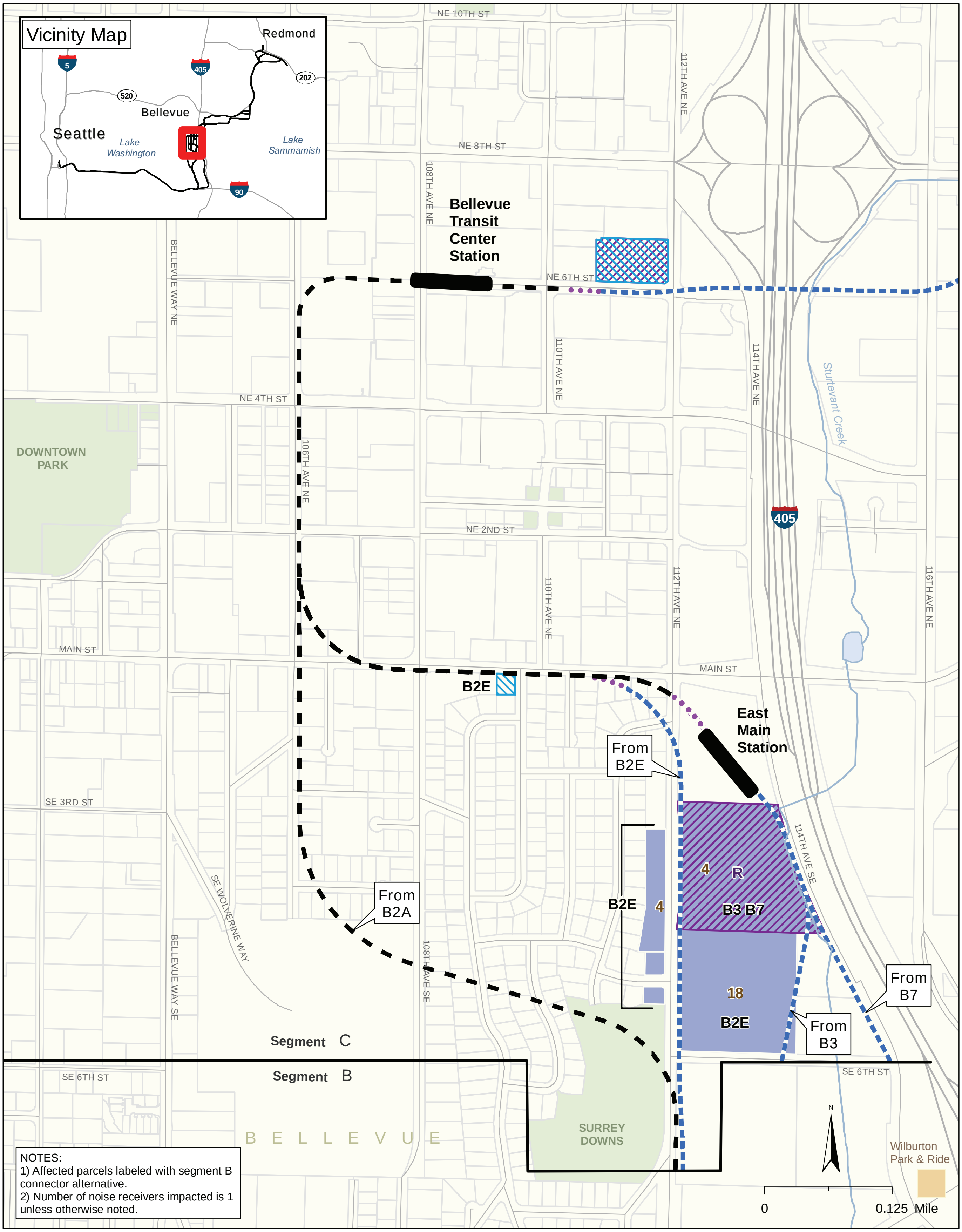
Exhibit A-7 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C1T**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
26 Number of Impacted Noise Receivers
R Residual Vibration Impact
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Proposed Station
Traction Power Substation

Exhibit A-8 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C1T**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

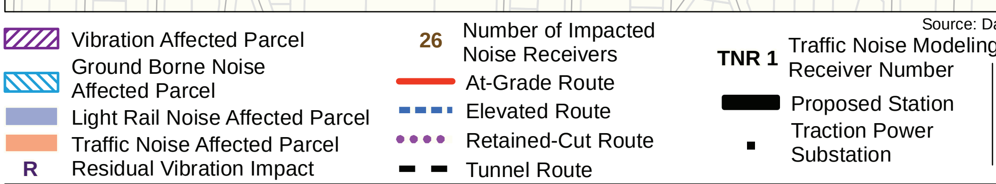
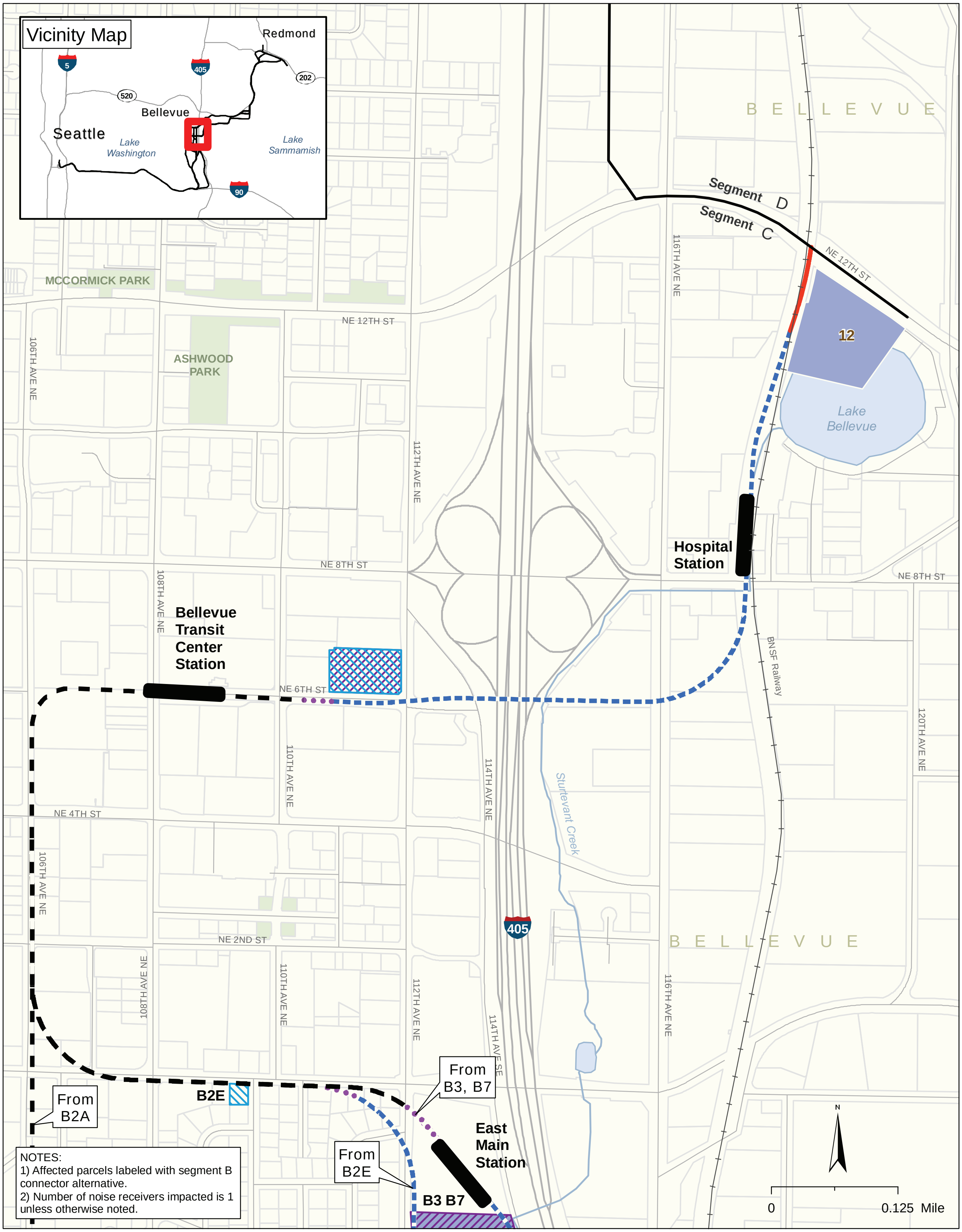


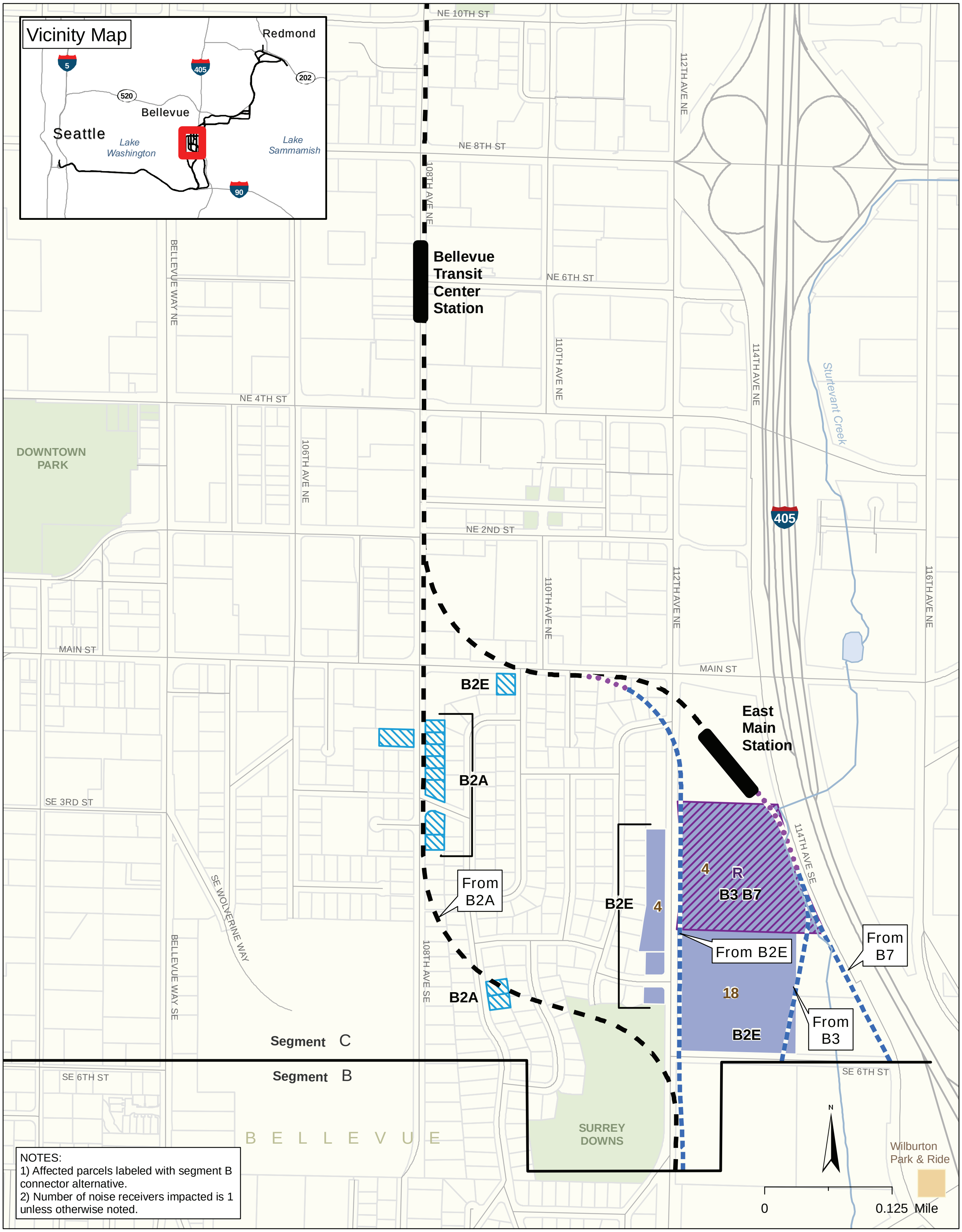
Exhibit A-9 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C2T**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
26 Number of Impacted Noise Receivers
R Residual Vibration Impact
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Proposed Station
Traction Power Substation

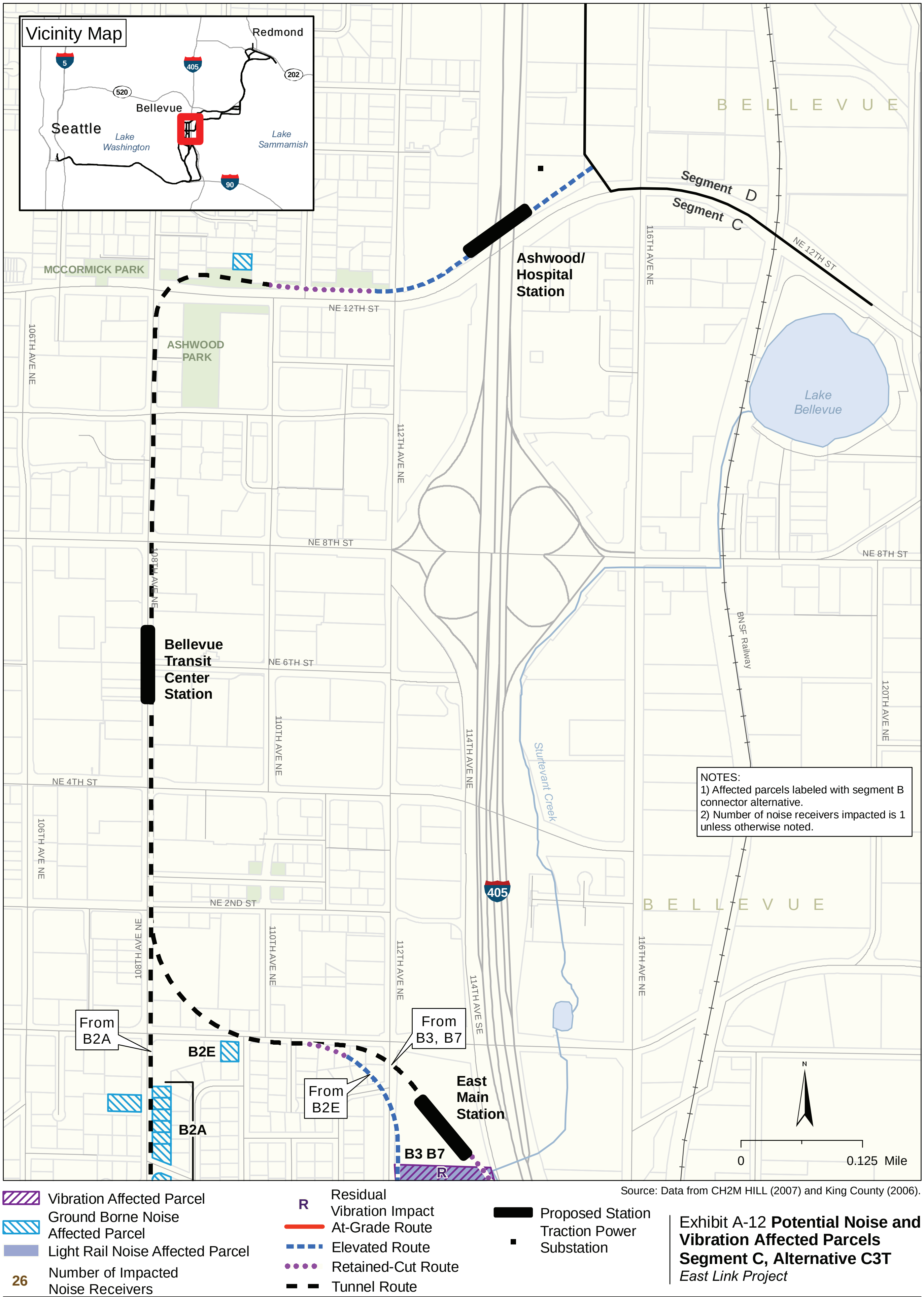
Exhibit A-10 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C2T**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

Exhibit A-11 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C3T**
East Link Project



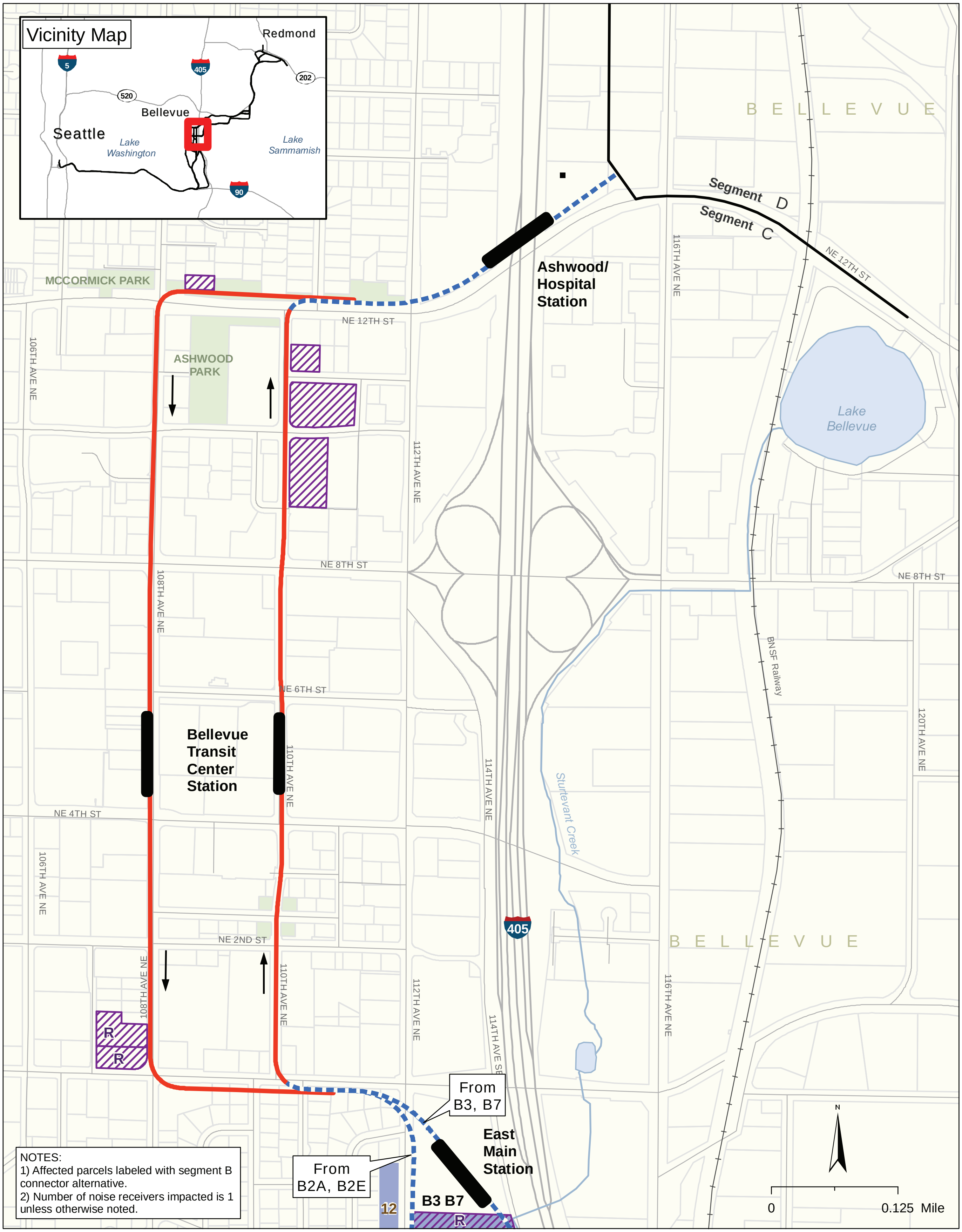
Source: Data from CH2M HILL (2007) and King County (2006).

Exhibit A-12 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C3T**
East Link Project

Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

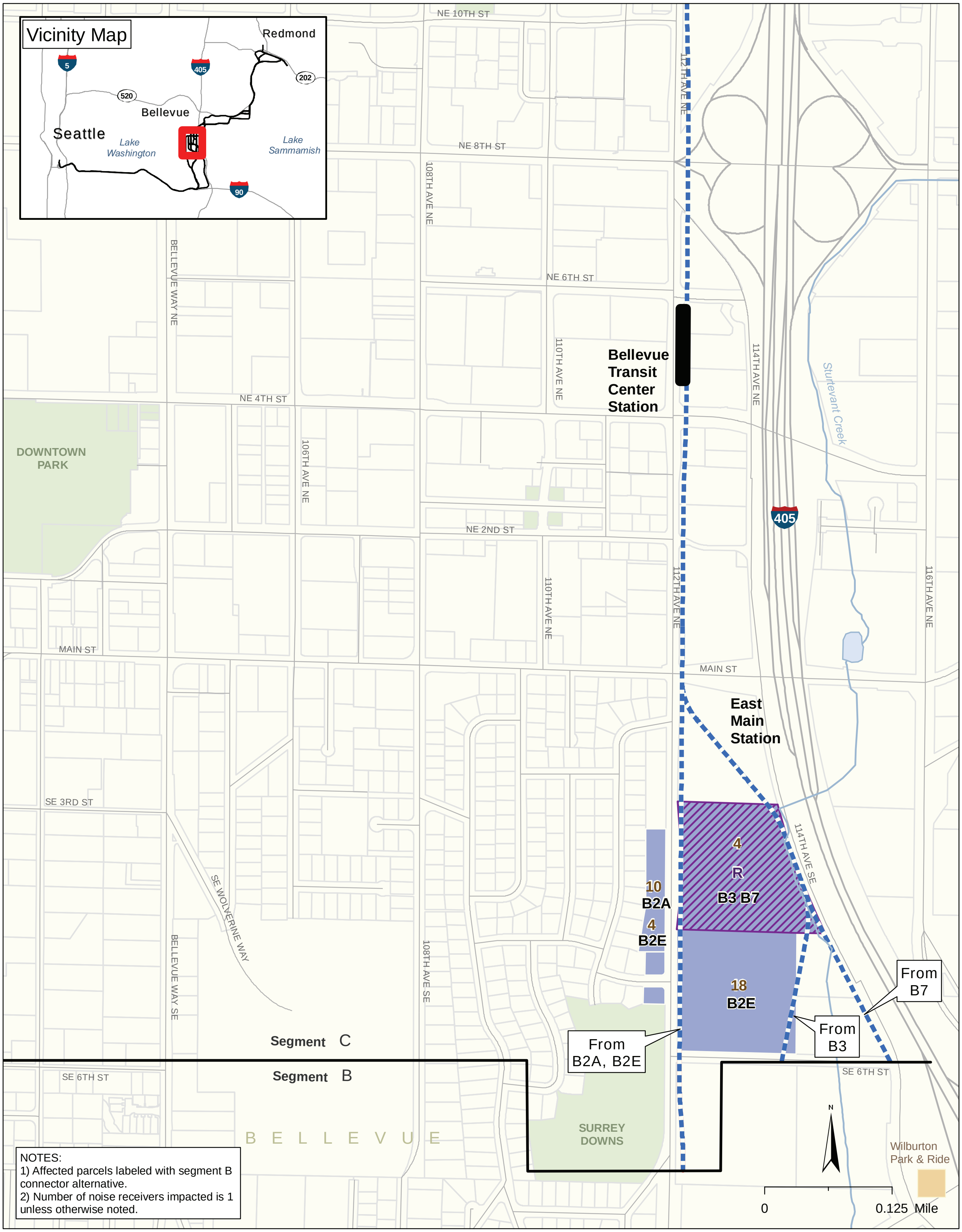
Exhibit A-13 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C4A**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
26 Number of Impacted Noise Receivers
R Residual Vibration Impact
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Proposed Station
Traction Power Substation

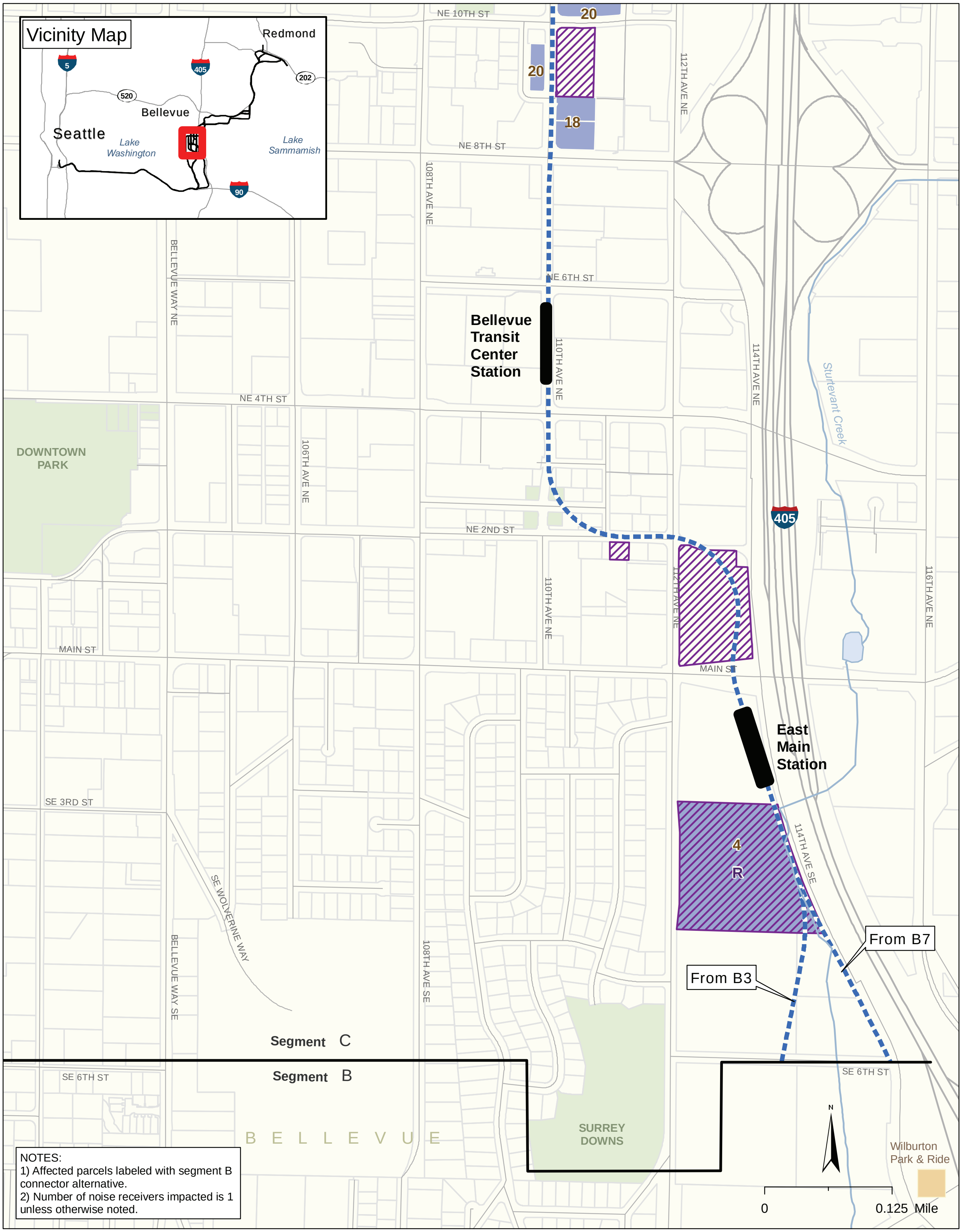
Exhibit A-14 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C4A**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

Exhibit A-15 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C7E**
East Link Project



NOTES:
1) Affected parcels labeled with segment B connector alternative.
2) Number of noise receivers impacted is 1 unless otherwise noted.

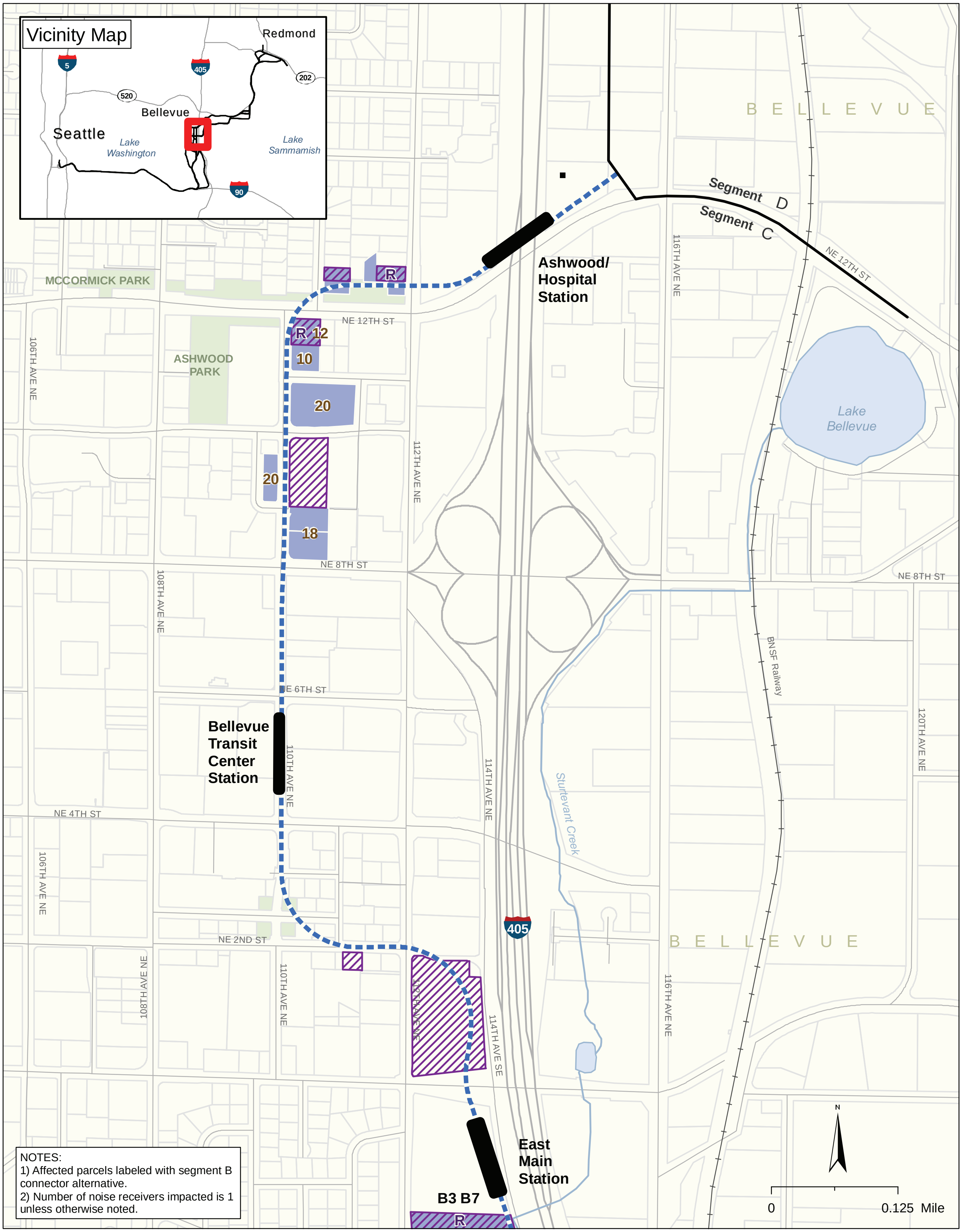
Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
Traffic Noise Affected Parcel
R Residual Vibration Impact

26 Number of Impacted Noise Receivers
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route

TNR 1 Traffic Noise Modeling Receiver Number
Proposed Station
Traction Power Substation

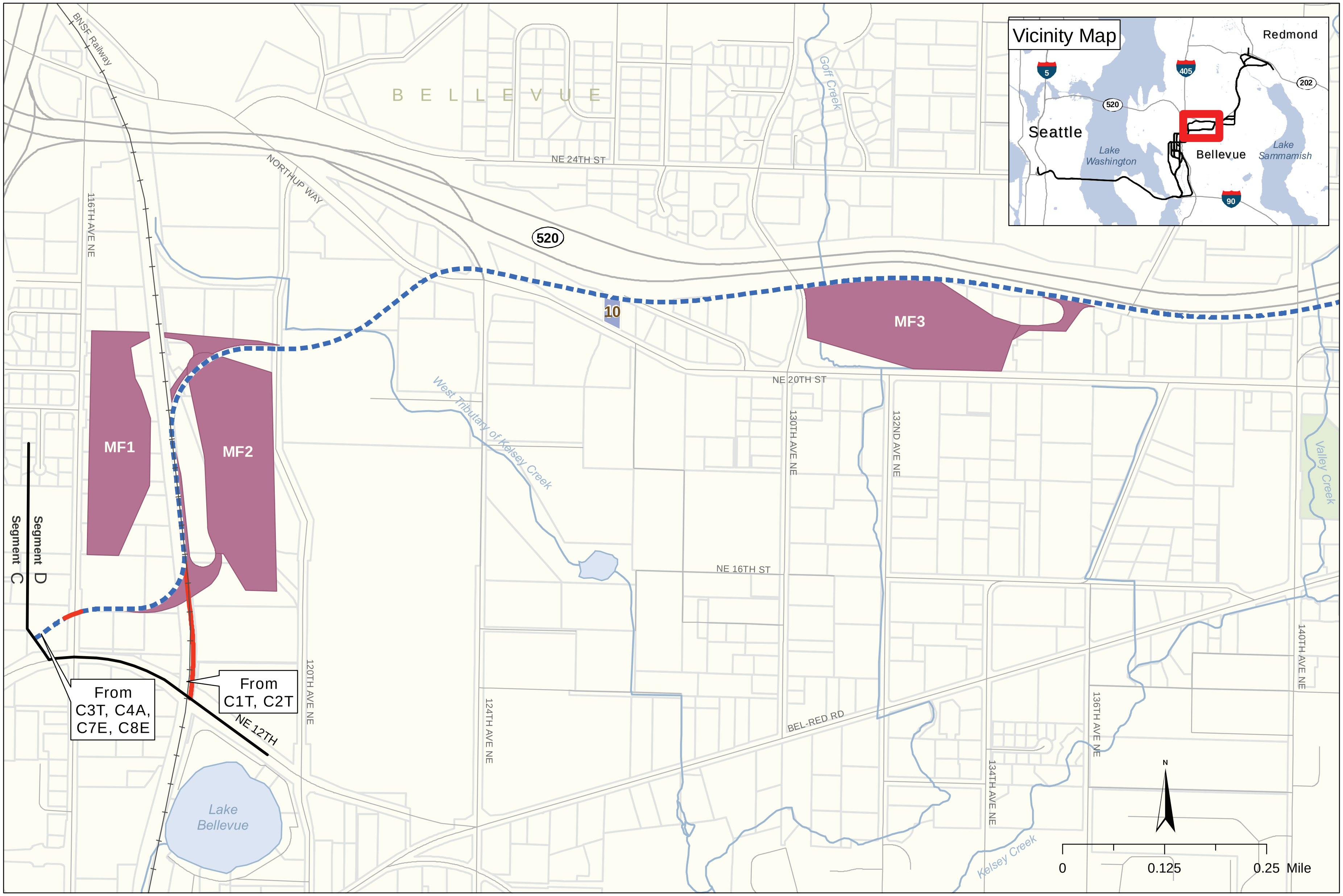
Exhibit A-16 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C8E**
East Link Project



Vibration Affected Parcel
Ground Borne Noise Affected Parcel
Light Rail Noise Affected Parcel
26 Number of Impacted Noise Receivers
R Residual Vibration Impact
At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Proposed Station
Traction Power Substation

Source: Data from CH2M HILL (2007) and King County (2006).

Exhibit A-17 **Potential Noise and Vibration Affected Parcels Segment C, Alternative C8E**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Light Rail Noise Affected Parcel

10 Number of Impacted Noise Receivers

At-Grade Route

Elevated Route

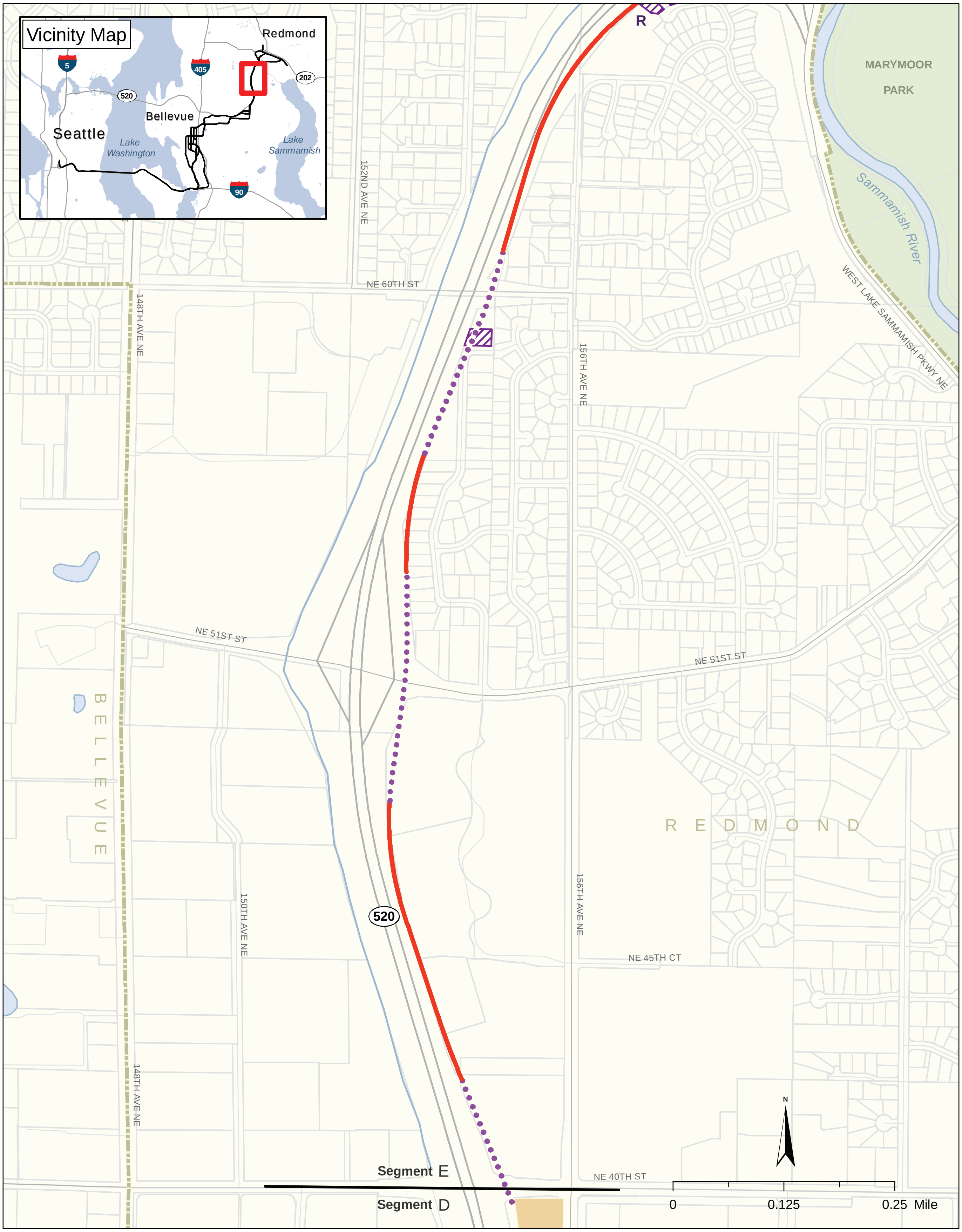
Retained-Cut Route

Tunnel Route

Maintenance Facility and Access Track

NOTES:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Exhibit A-18 **Potential Noise and Vibration Affected Parcels Segment D, Alternative D5**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

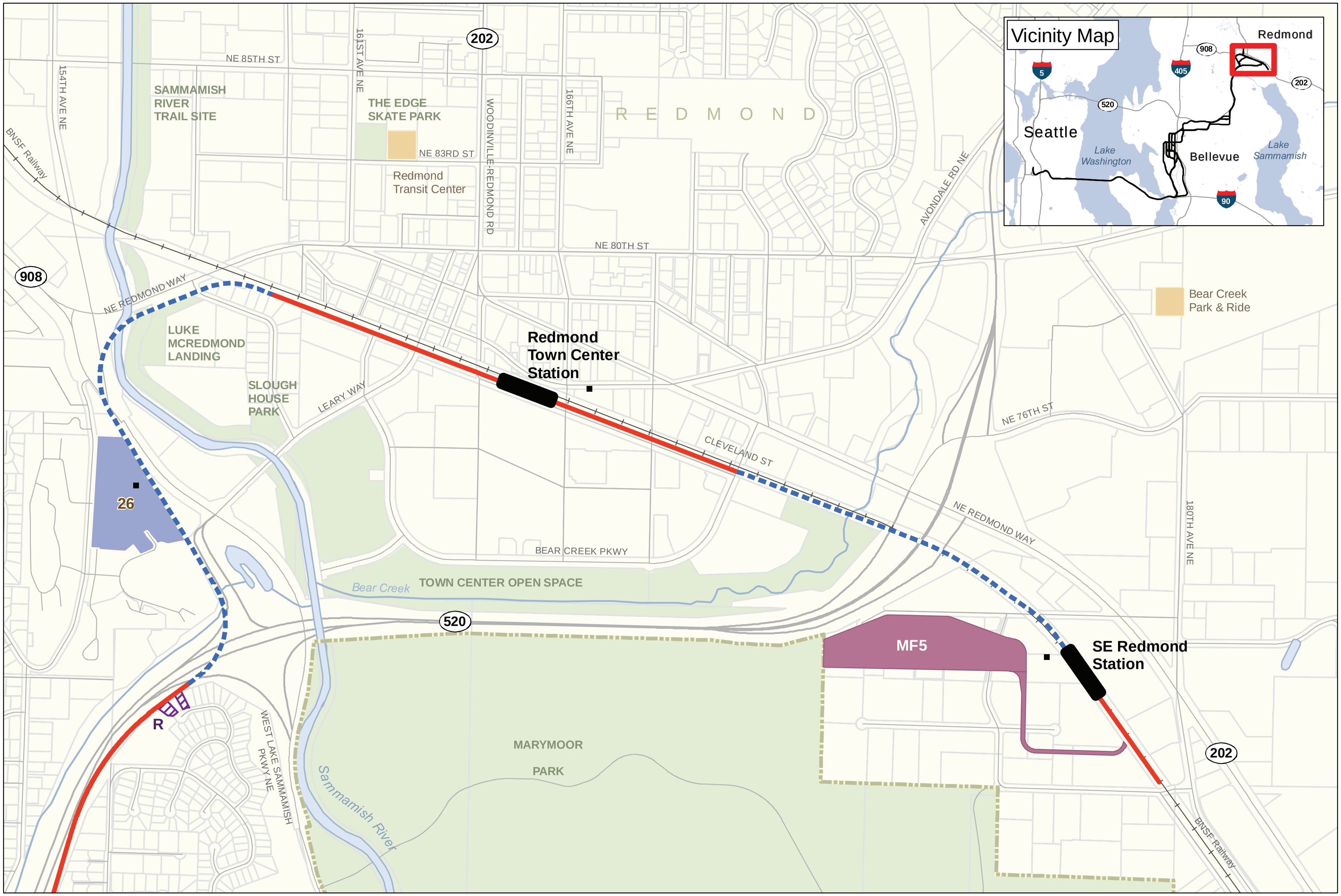
Vibration Affected Parcel
Light Rail Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route

Traction Power Substation
Proposed Station

NOTES:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Exhibit A-19 **Potential Noise and Vibration Affected Parcels Segment E, Alternative E1**
East Link Project



Vibration Affected Parcel
Light Rail Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Proposed Station

Traction Power Substation
Maintenance Facility and Access Track

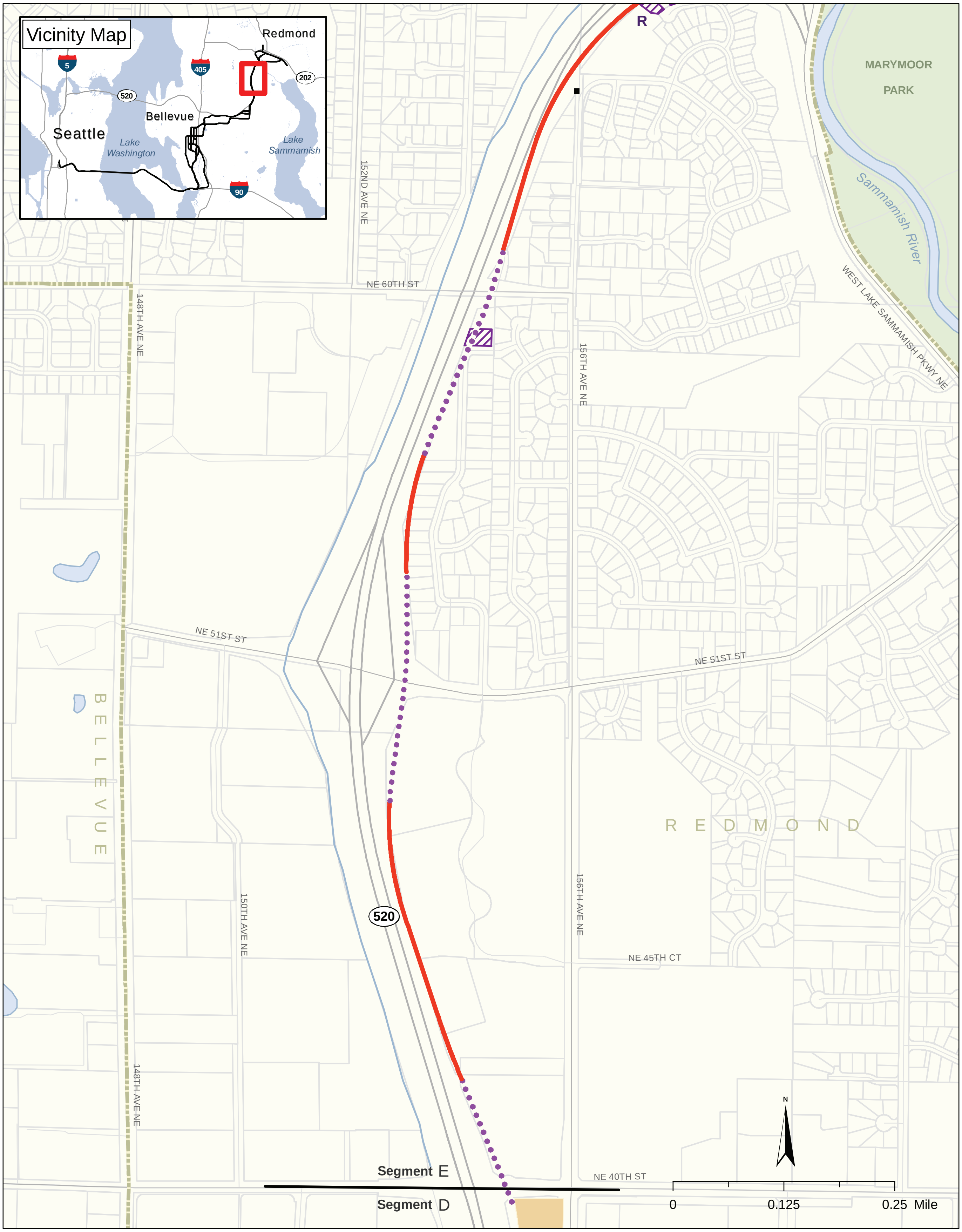
NOTES:
1) Number of noise receivers impacted is 1 unless otherwise noted.

N

0 0.125 0.25 Mile

Source: Data from CH2M HILL (2007) and King County (2006).

Exhibit A-20 **Potential Noise and Vibration Affected Parcels Segment E, Alternative E1**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

Vibration Affected Parcel
Light Rail Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route

Traction Power Substation
Proposed Station

NOTES:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Exhibit A-21 **Potential Noise and Vibration Affected Parcels Segment E, Alternative E2**
East Link Project

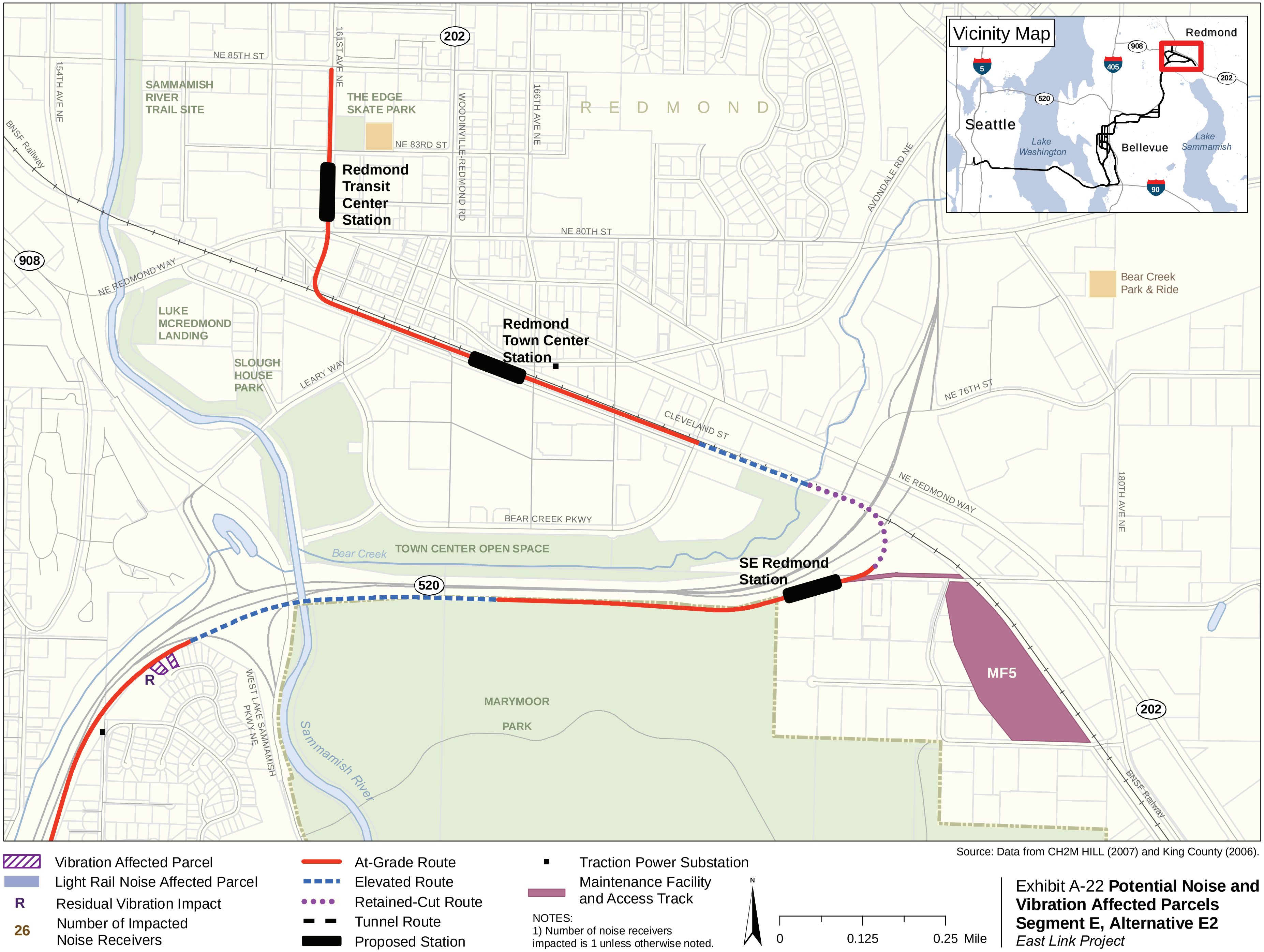
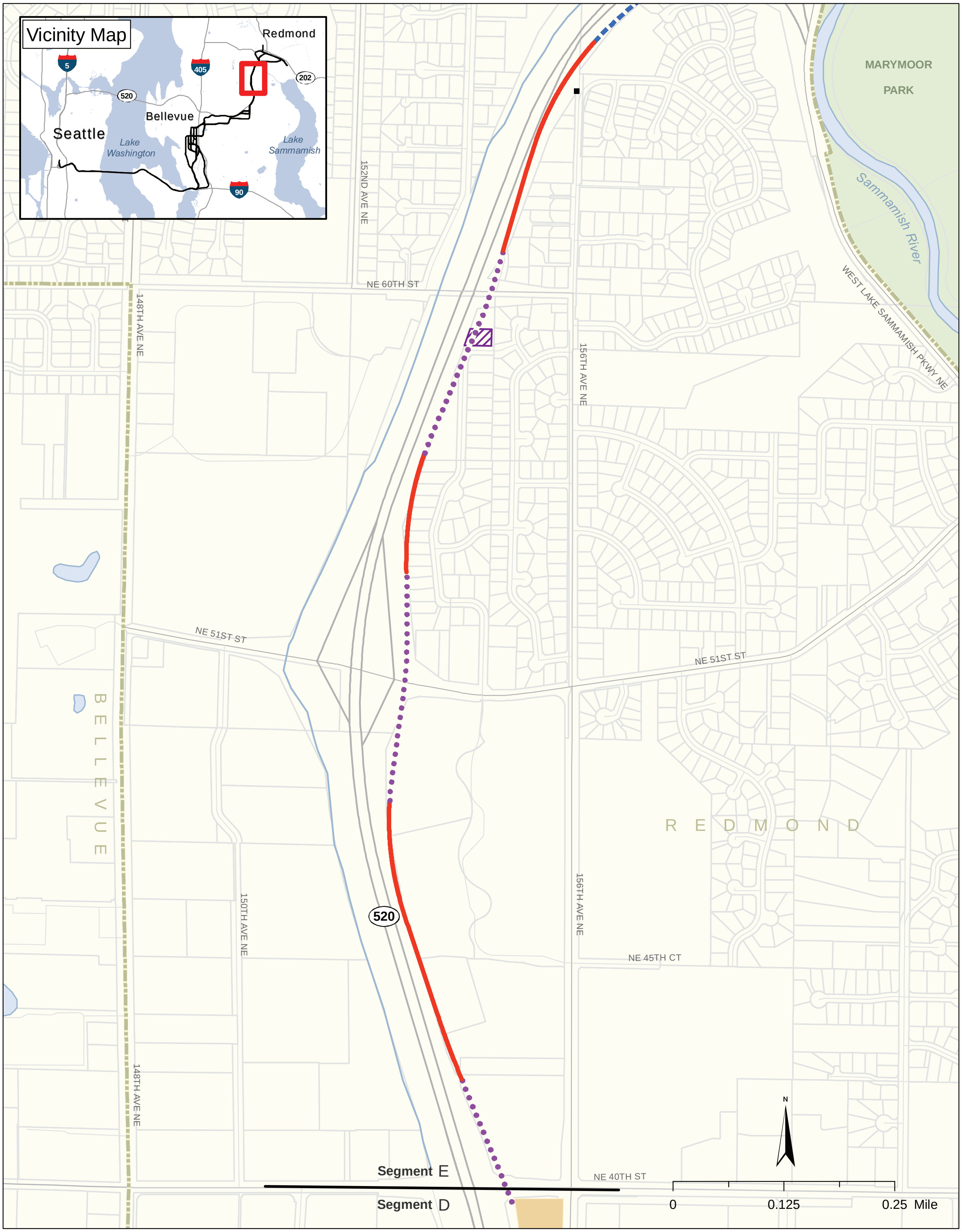


Exhibit A-22 **Potential Noise and Vibration Affected Parcels Segment E, Alternative E2**
East Link Project



Source: Data from CH2M HILL (2007) and King County (2006).

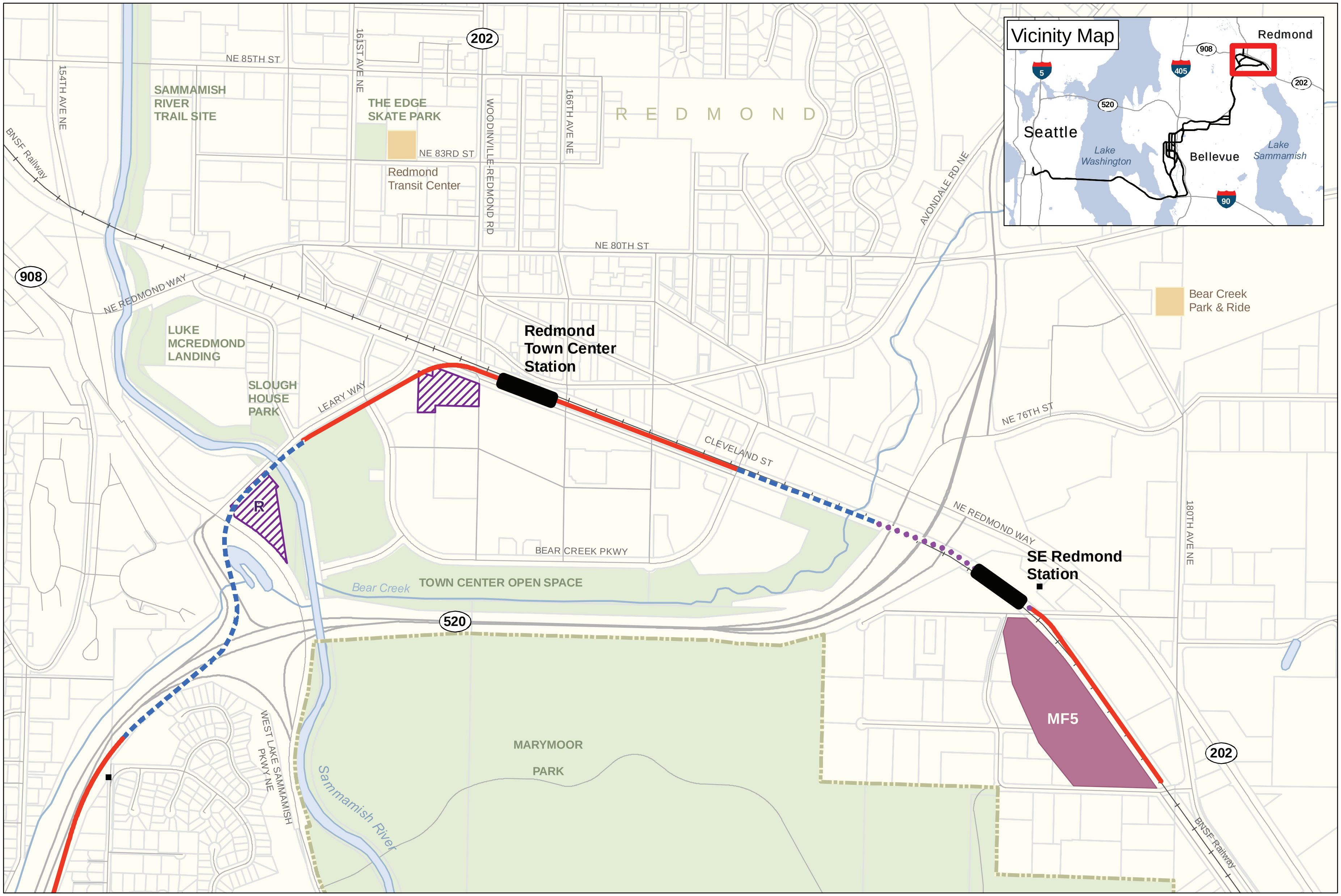
Vibration Affected Parcel
Light Rail Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route

Traction Power Substation
Proposed Station

NOTES:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Exhibit A-23 **Potential Noise and Vibration Affected Parcels Segment E, Alternative E4**
East Link Project



Vibration Affected Parcel
Light Rail Noise Affected Parcel
R Residual Vibration Impact
26 Number of Impacted Noise Receivers

At-Grade Route
Elevated Route
Retained-Cut Route
Tunnel Route
Proposed Station

Traction Power Substation
Maintenance Facility and Access Track

NOTES:
1) Number of noise receivers impacted is 1 unless otherwise noted.

Source: Data from CH2M HILL (2007) and King County (2006).

Exhibit A-24 **Potential Noise and Vibration Affected Parcels Segment E, Alternative E4**
East Link Project

Appendix B

Vibration Measurement Site Photographs

EXHIBIT B-1
Site V-1, 32nd Avenue and South Day Street, Seattle

EXHIBIT B-2
Site V-2, South Bellevue Park-and-Ride Lot, Bellevue

EXHIBIT B-3
Site V-3, King County District Court Parking Lot, Bellevue

EXHIBIT B-4
Site V-4, NE 12th Street Bore Hole, Bellevue

EXHIBIT B-5
Site V-5, Overlake Hospital, Bellevue

EXHIBIT B-6
Site V-6, King County Park, Bellevue

EXHIBIT B-7
Site V-7, 154th Avenue and NE54th Street, Redmond

EXHIBIT B-8
Site V-8, Redmond Town Center, Redmond

Appendix C

Noise Measurement Data

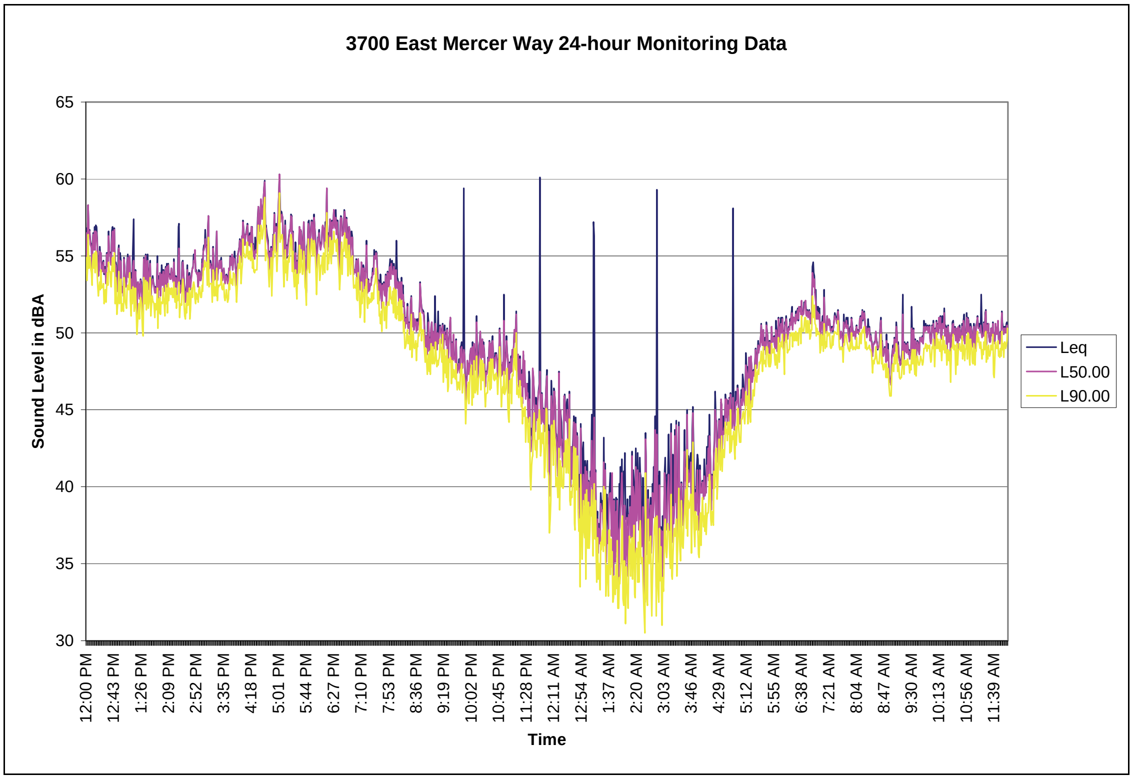


EXHIBIT C-1
Noise Survey Results, Site MA-5

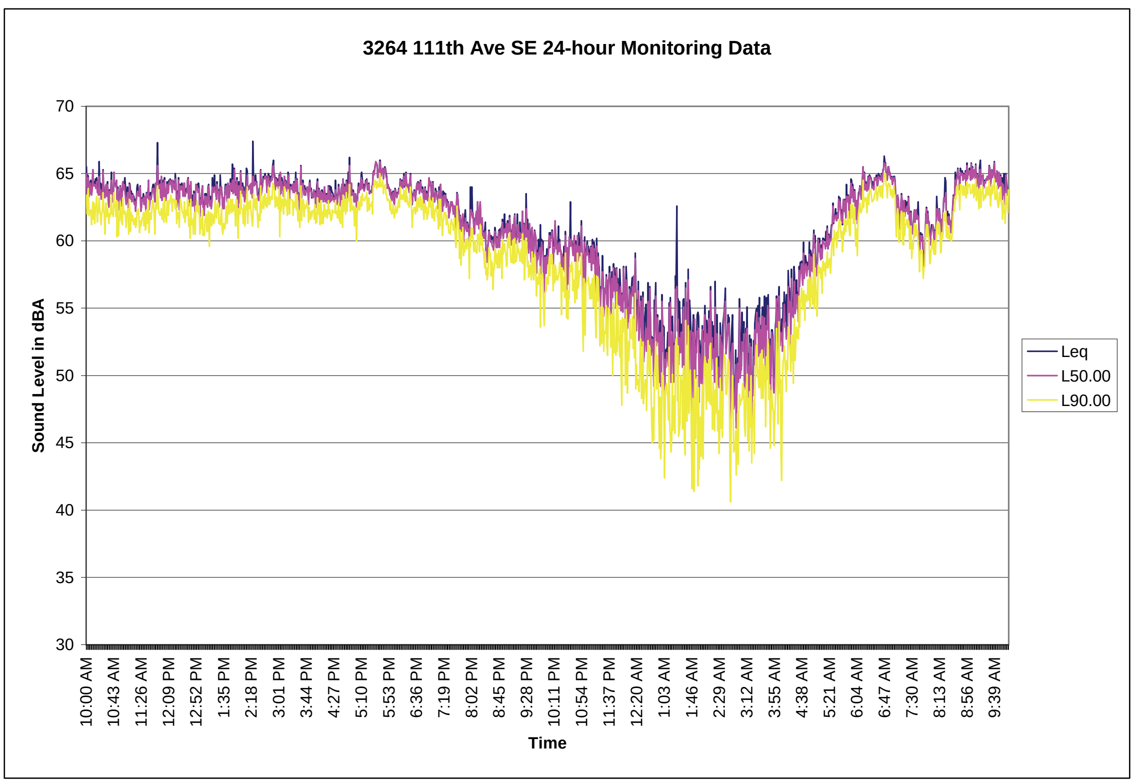


EXHIBIT C-2
Noise Survey Results, Site MB-4

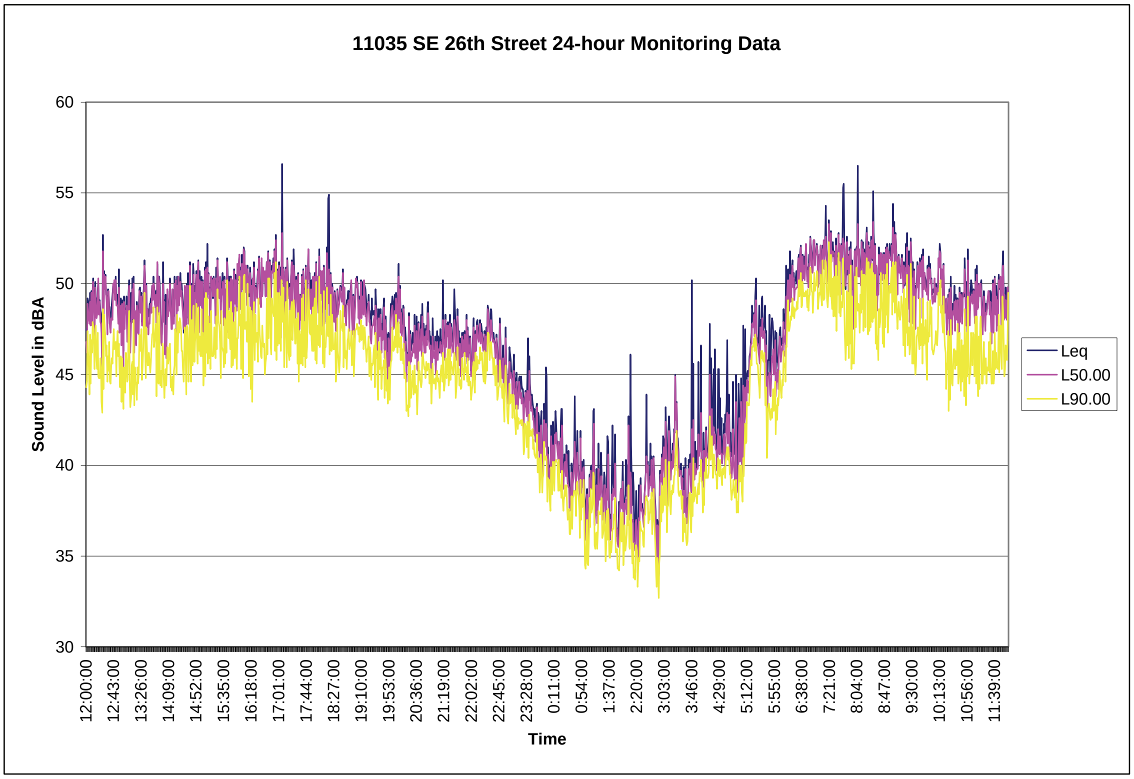


EXHIBIT C-3
Noise Survey Results, Site MB-7

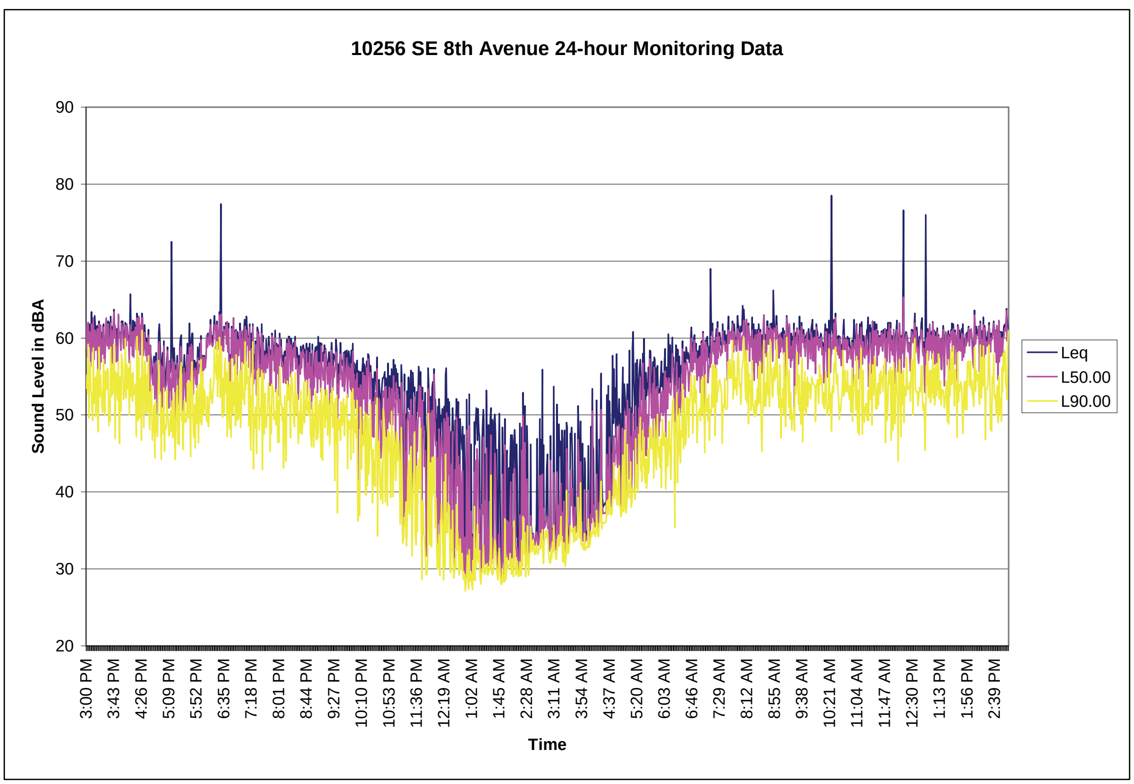


EXHIBIT C-4
Noise Survey Results, Site MB-13

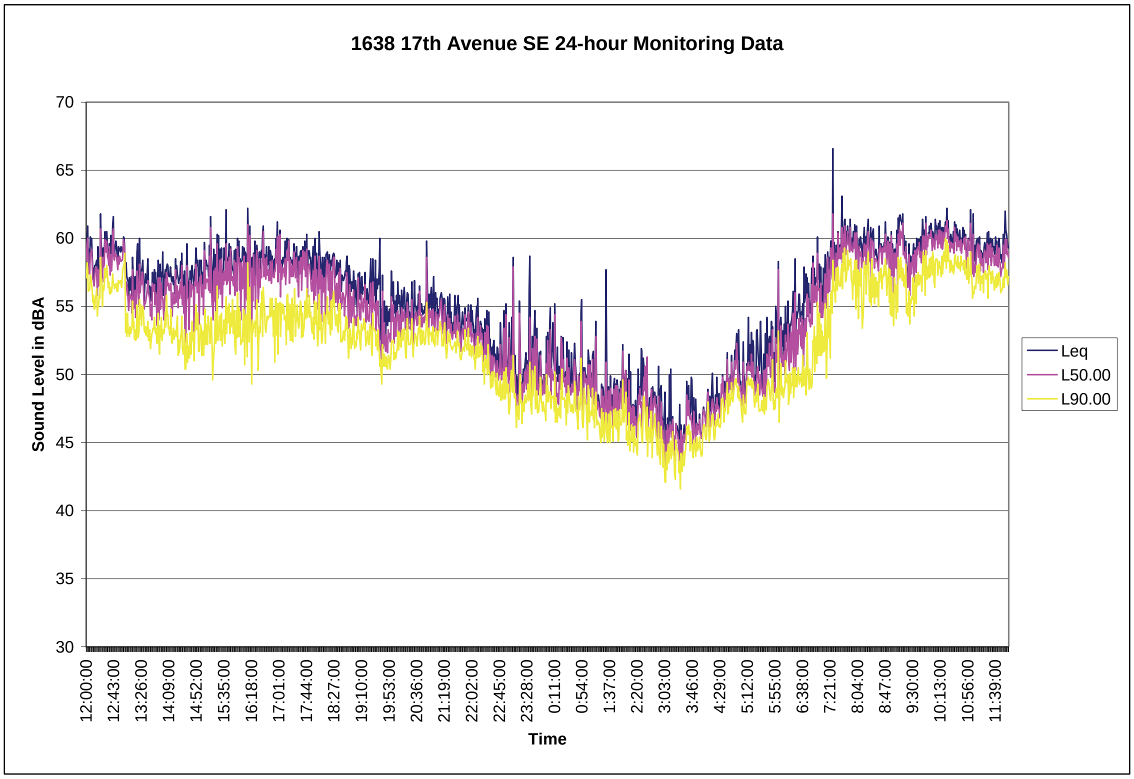


EXHIBIT C-5
Noise Survey Results, Site MB-14

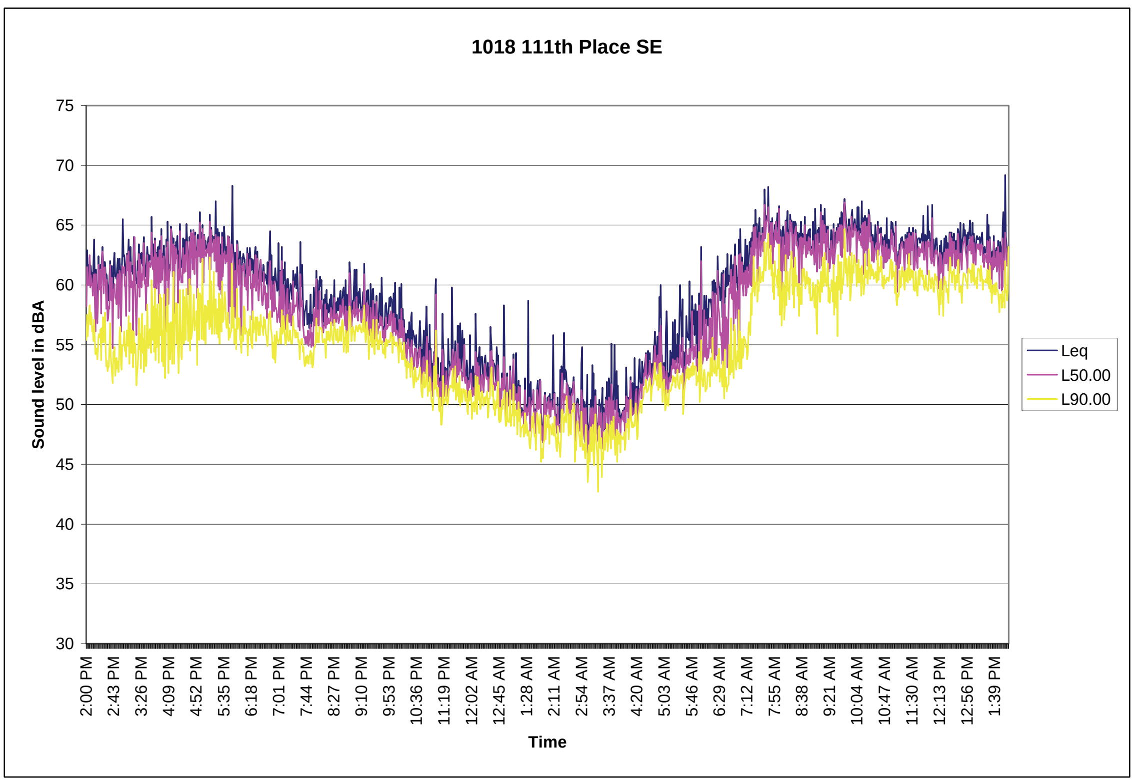


EXHIBIT C-6
Noise Survey Results, Site MB-16

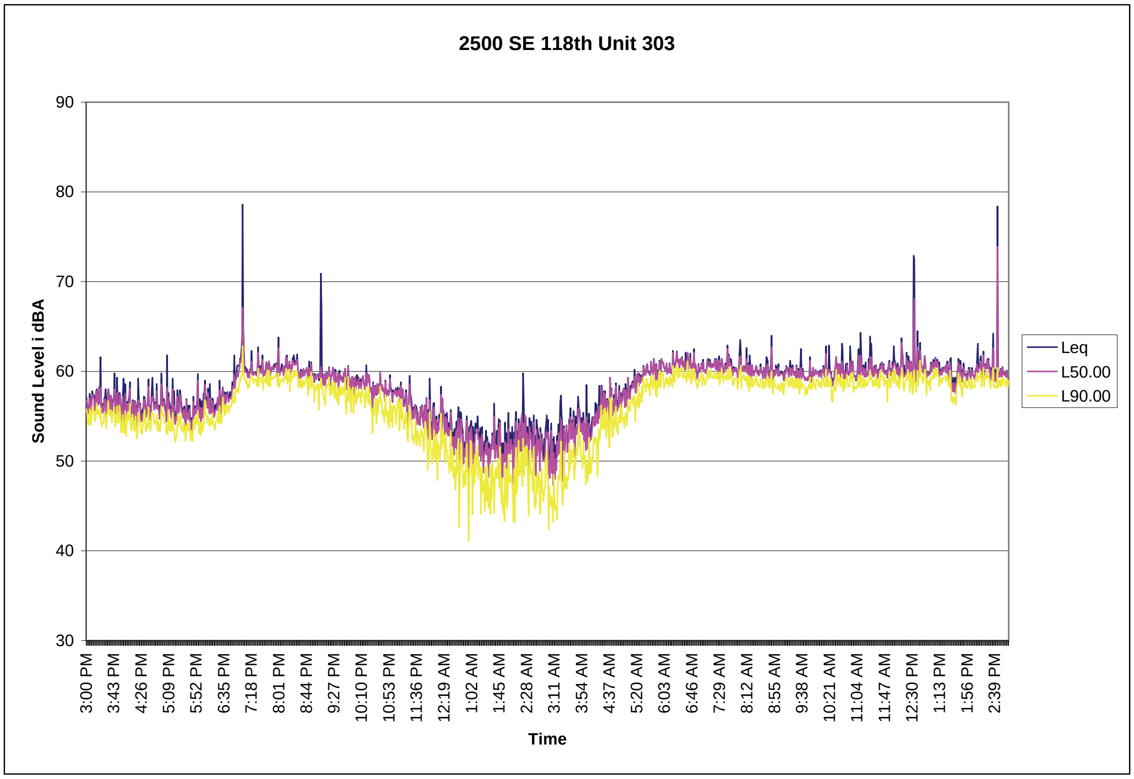


EXHIBIT C-7
Noise Survey Results, Site MB-18

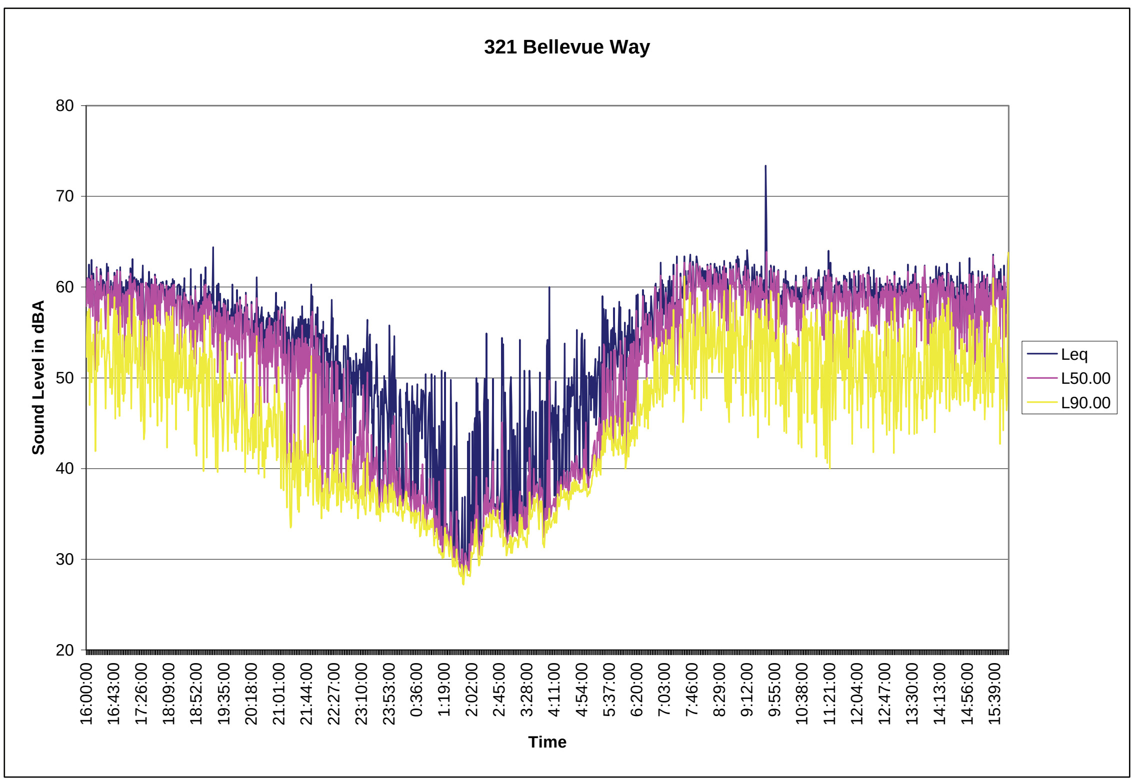


EXHIBIT C-8
Noise Survey Results, Site MC-2

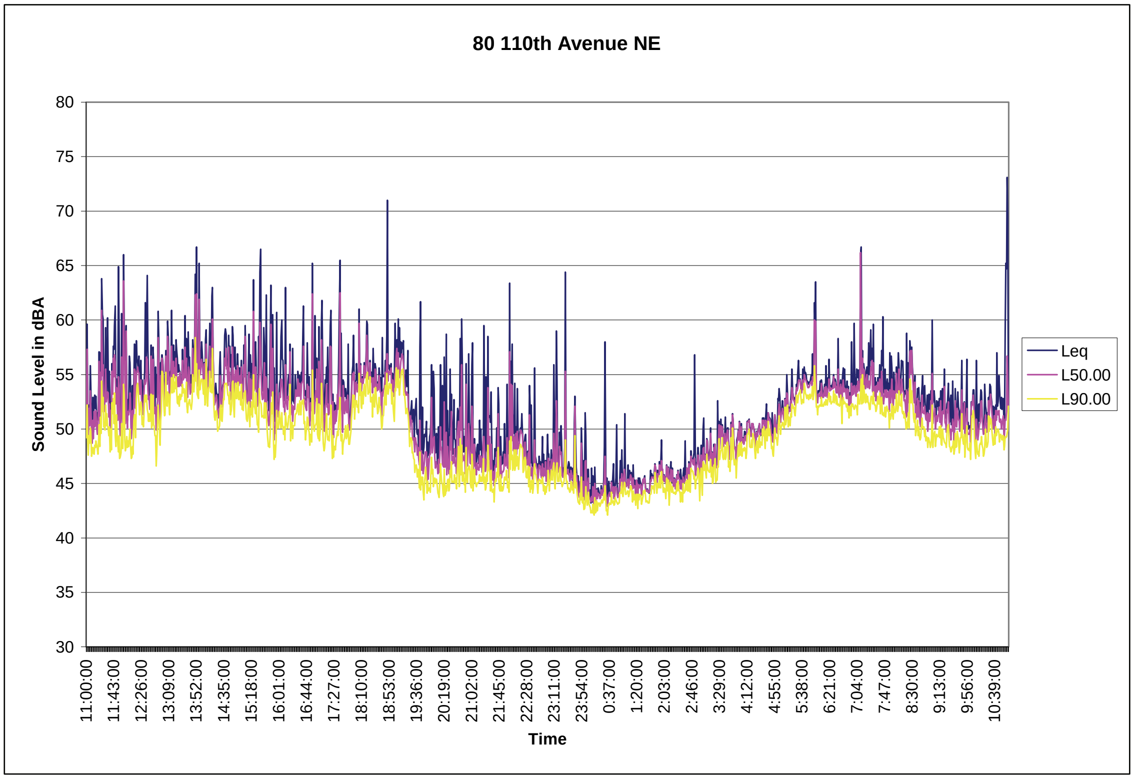


EXHIBIT C-9
Noise Survey Results, Site MC-6

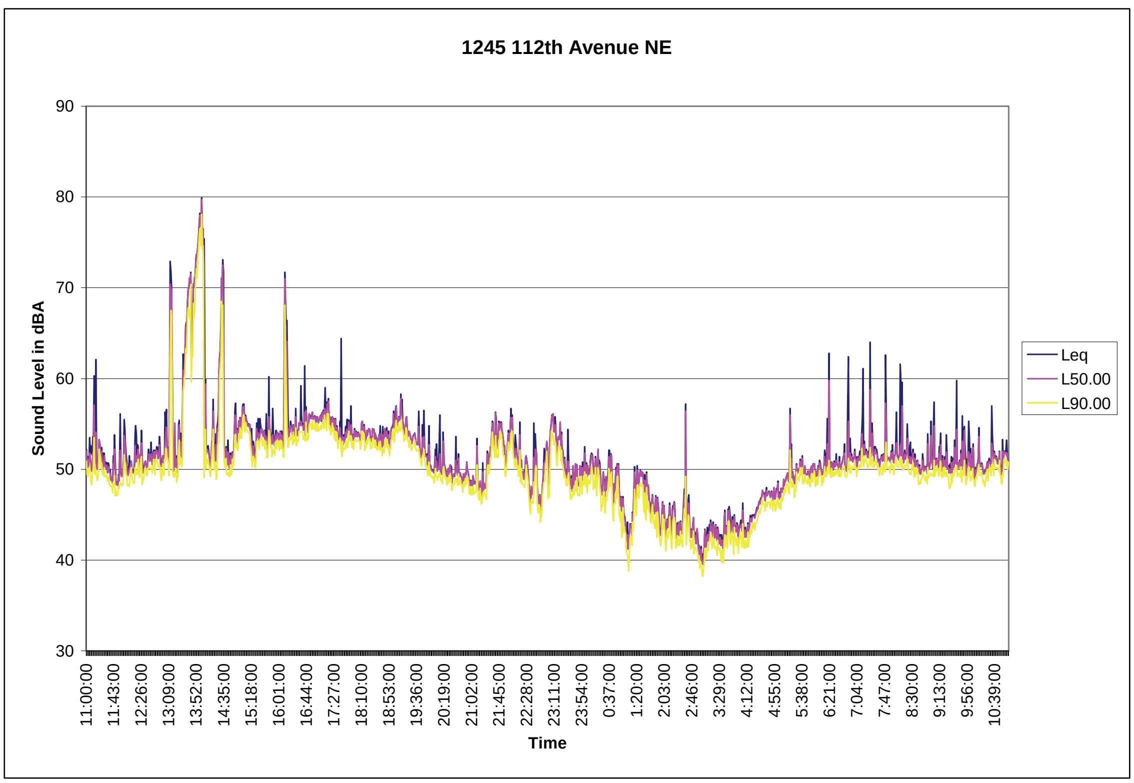


EXHIBIT C-10
Noise Survey Results, Site MC-13

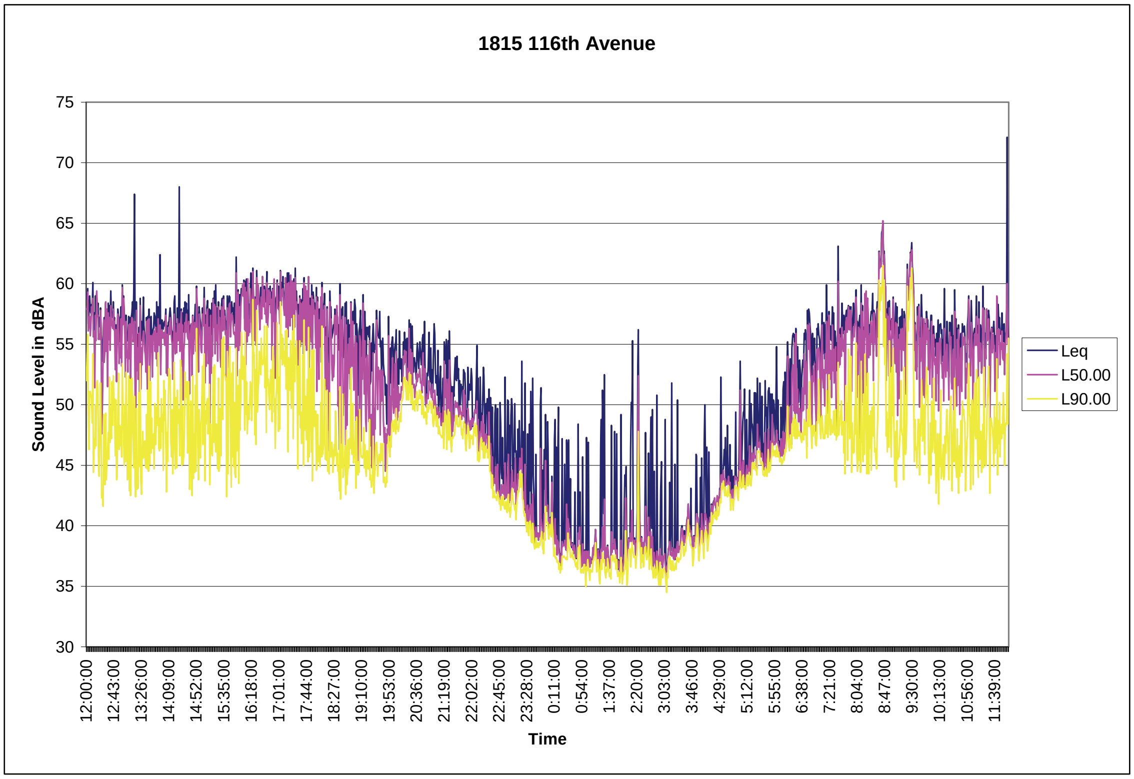


EXHIBIT C-11
Noise Survey Results, Site MD-1

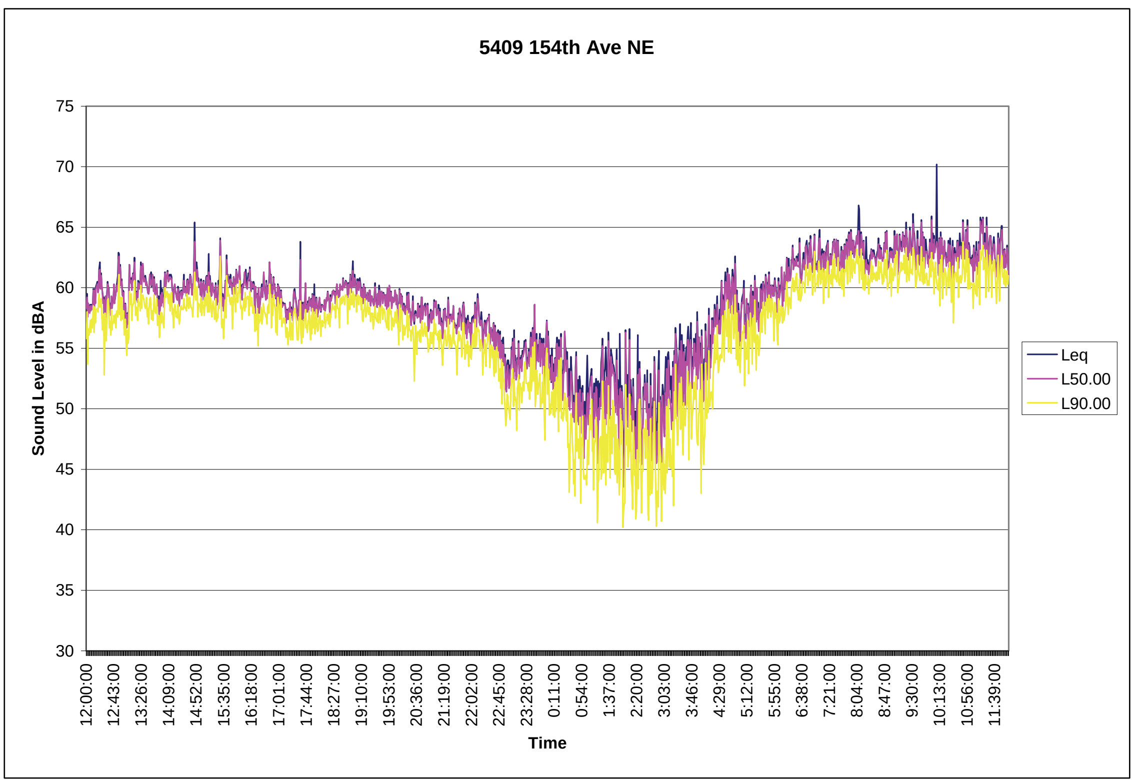


EXHIBIT C-12
Noise Survey Results, Site ME-1

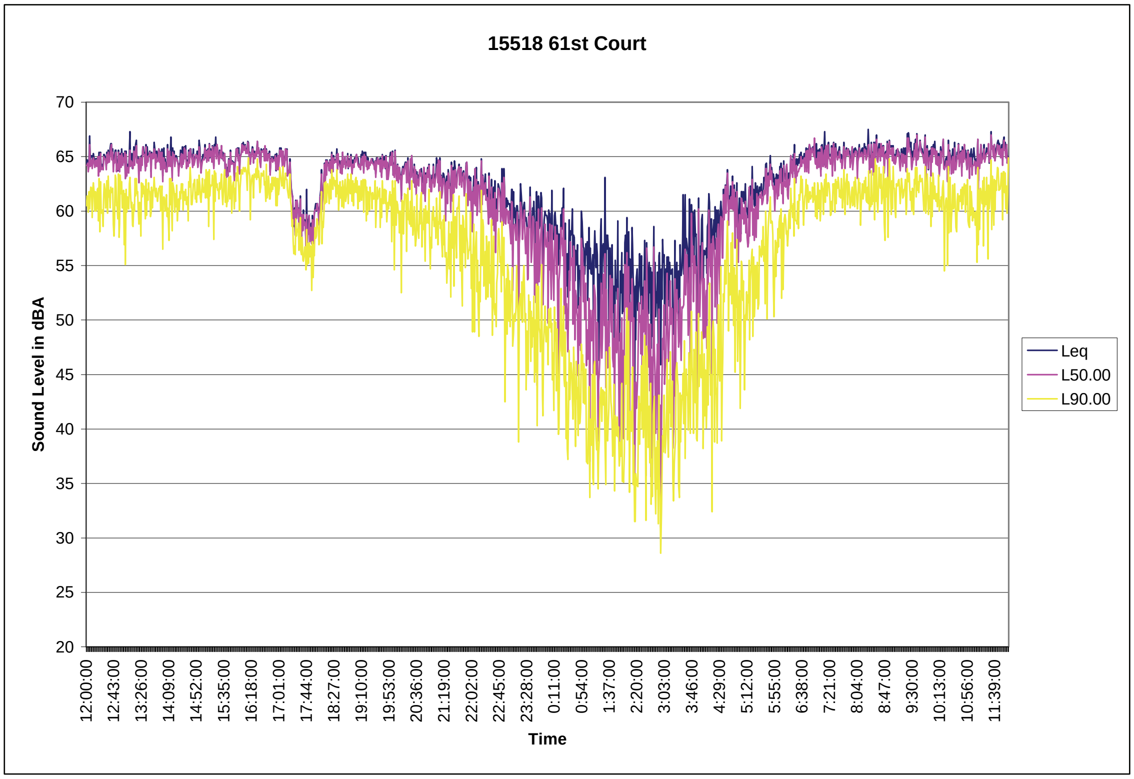


EXHIBIT C-13
Noise Survey Results, Site ME-2

Appendix D

Vibration Propagation Data

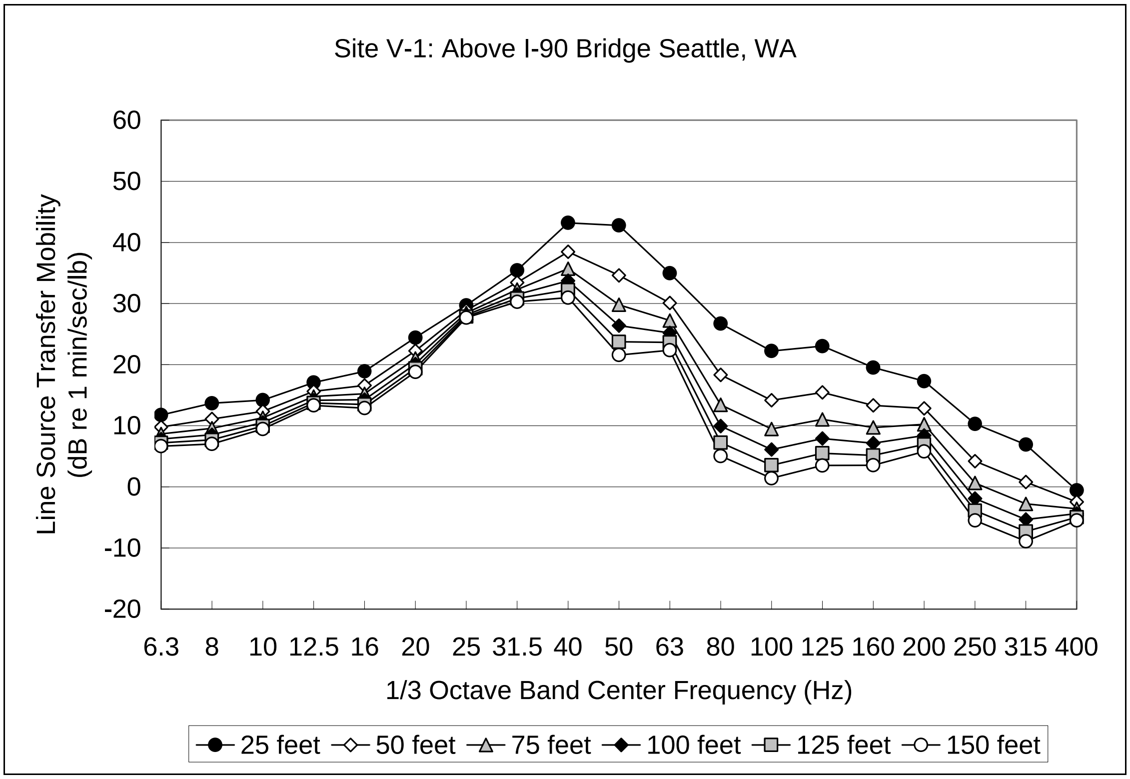


EXHIBIT D-1
Representative Transfer Mobility Functions, Site V-1

TABLE D-1
Line Source Transfer Mobility Coefficients, Site V-1

Frequency (Hz)	A	B	C
6.3	20.90	-6.54	0.00
8	25.70	-8.59	0.00
10	22.71	-6.09	0.00
12.5	23.84	-4.83	0.00
16	29.75	-7.75	0.00
20	34.46	-7.19	0.00
25	33.31	-2.59	0.00
31.5	44.65	-6.59	0.00
40	65.18	-15.72	0.00
50	80.85	-27.23	0.00
63	57.65	-16.22	0.00
80	65.58	-27.82	0.00
100	59.63	-26.75	0.00
125	58.09	-25.09	0.00
160	48.20	-20.53	0.00
200	37.98	-14.79	0.00
250	38.69	-20.30	0.00
315	35.41	-20.37	0.00
400	8.33	-6.35	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

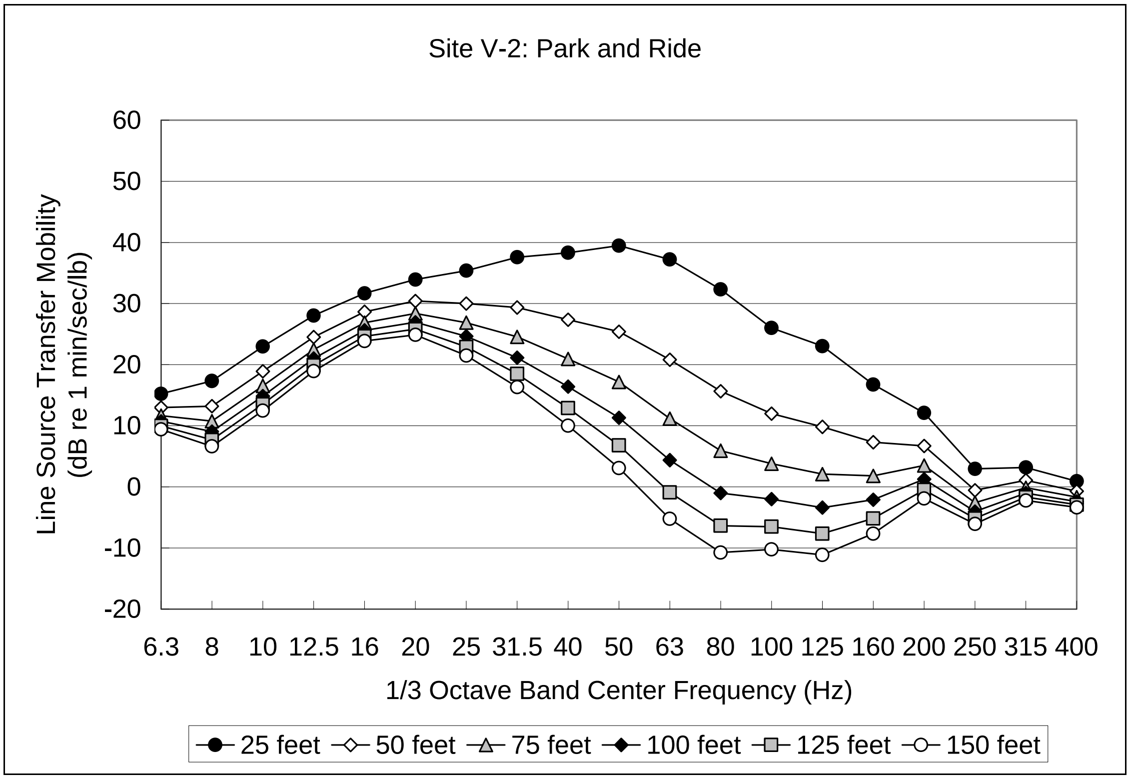


EXHIBIT D-2
Representative Transfer Mobility Functions, Site V-2

TABLE D-2
Line Source Transfer Mobility Coefficients, Site V-2

Frequency (Hz)	A	B	C
6.3	25.72	-7.50	0.00
8	36.60	-13.78	0.00
10	41.86	-13.51	0.00
12.5	44.36	-11.68	0.00
16	45.70	-10.04	0.00
20	50.22	-11.65	0.00
25	60.29	-17.83	0.00
31.5	75.75	-27.32	0.00
40	89.18	-36.39	0.00
50	104.88	-46.78	0.00
63	113.52	-54.58	0.00
80	109.72	-55.36	0.00
100	91.03	-46.53	0.00
125	84.38	-43.89	0.00
160	60.52	-31.32	0.00
200	37.29	-18.02	0.00
250	19.18	-11.61	0.00
315	12.88	-6.95	0.00
400	8.64	-5.51	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2
d = Distance in feet

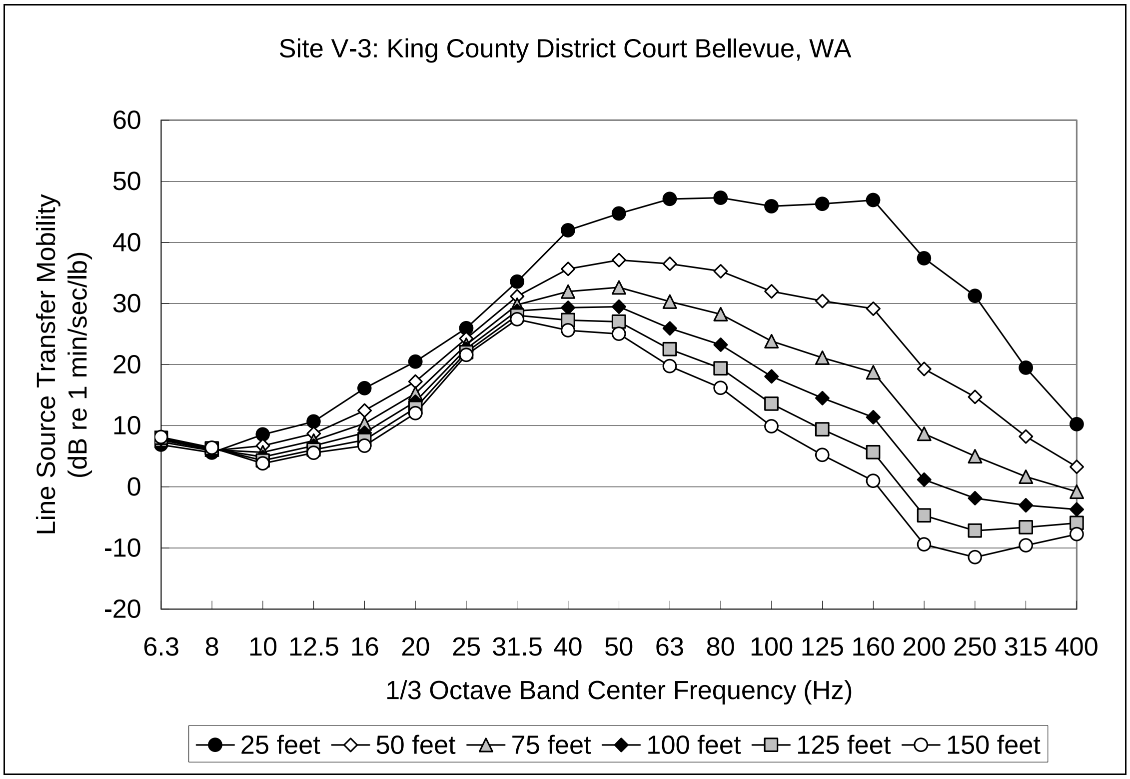


EXHIBIT D-3
Representative Transfer Mobility Functions, Site V-3

TABLE D-3
Line Source Transfer Mobility Coefficients, Site V-3

Frequency (Hz)	A	B	C
6.3	4.64	1.61	0.00
8	4.20	1.00	0.00
10	17.12	-6.12	0.00
12.5	19.90	-6.59	0.00
16	33.04	-12.10	0.00
20	35.67	-10.86	0.00
25	33.81	-5.62	0.00
31.5	44.59	-7.89	0.00
40	71.43	-21.06	0.00
50	80.08	-25.30	0.00
63	96.25	-35.16	0.00
80	103.20	-39.98	0.00
100	110.57	-46.26	0.00
125	120.12	-52.80	0.00
160	129.38	-59.00	0.00
200	121.57	-60.20	0.00
250	108.07	-54.96	0.00
315	71.75	-37.38	0.00
400	42.48	-23.08	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2
d = Distance in feet

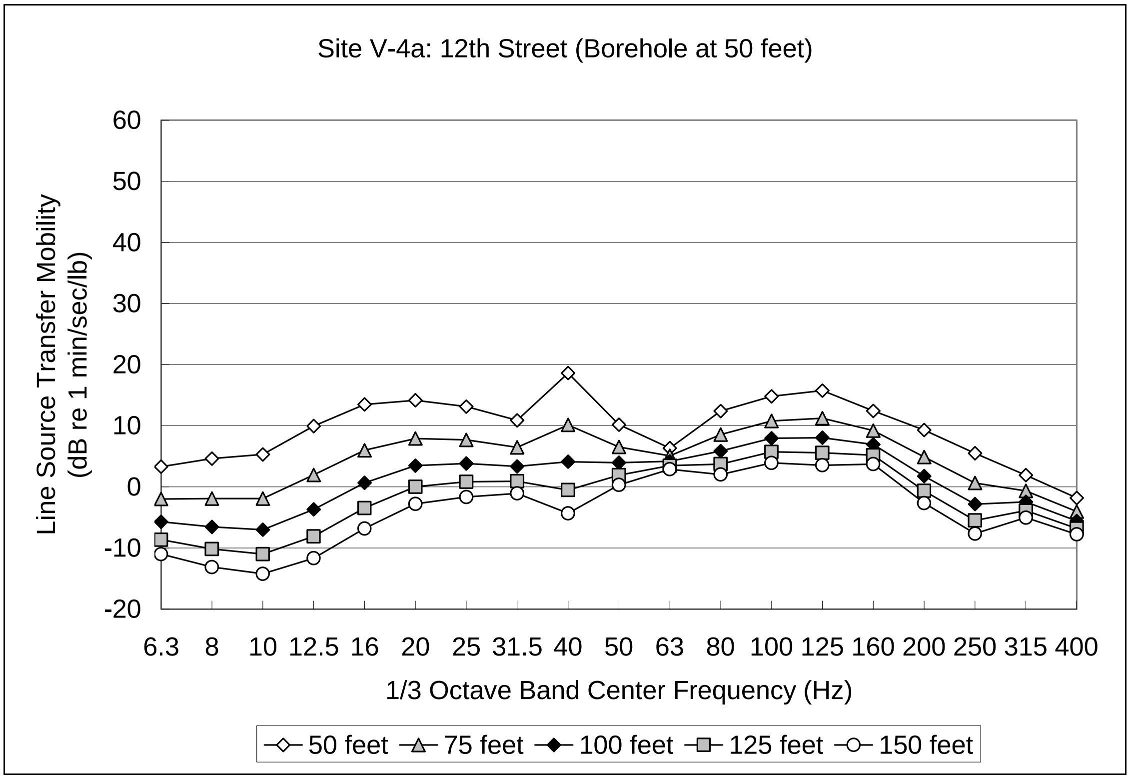


EXHIBIT D-4
Representative Transfer Mobility Functions, Site V-4a

TABLE D-4
Line Source Transfer Mobility Coefficients, Site V-4a

Frequency (Hz)	A	B	C
6.3	54.32	-30.02	0.00
8	67.81	-37.19	0.00
10	74.90	-40.96	0.00
12.5	86.94	-45.32	0.00
16	85.84	-42.59	0.00
20	74.60	-35.56	0.00
25	65.84	-31.01	0.00
31.5	53.44	-25.05	0.00
40	100.37	-48.12	0.00
50	45.32	-20.69	0.00
63	18.58	-7.21	0.00
80	49.34	-21.75	0.00
100	53.58	-22.82	0.00
125	59.29	-25.62	0.00
160	43.36	-18.21	0.00
200	51.86	-25.06	0.00
250	52.39	-27.60	0.00
315	26.59	-14.53	0.00
400	19.37	-12.48	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

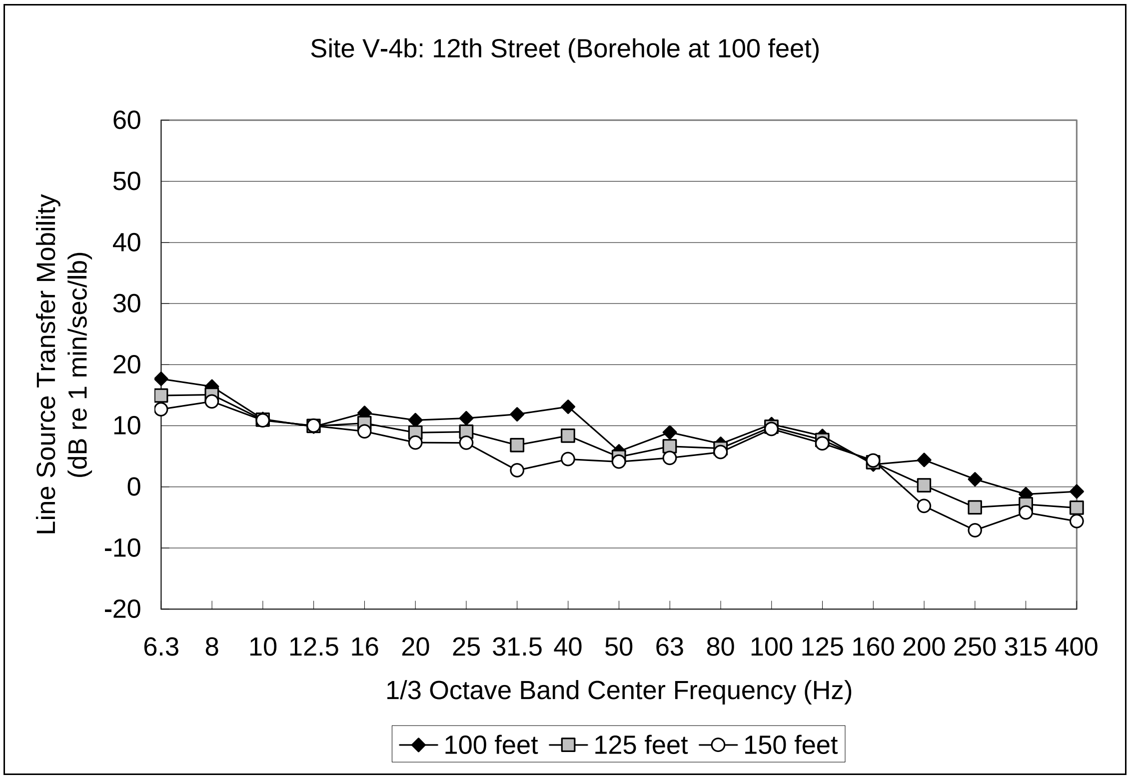


EXHIBIT D-5
Representative Transfer Mobility Functions, Site V-4b

TABLE D-5
Line Source Transfer Mobility Coefficients, Site V-4b

Frequency (Hz)	A	B	C
6.3	74.56	-28.43	0.00
8	43.93	-13.76	0.00
10	13.57	-1.24	0.00
12.5	8.10	0.88	0.00
16	46.57	-17.23	0.00
20	52.61	-20.86	0.00
25	57.16	-22.96	0.00
31.5	115.84	-51.99	0.00
40	110.36	-48.64	0.00
50	25.25	-9.71	0.00
63	56.46	-23.77	0.00
80	22.62	-7.79	0.00
100	19.32	-4.53	0.00
125	22.24	-6.96	0.00
160	-3.78	3.72	0.00
200	90.02	-42.81	0.00
250	95.93	-47.35	0.00
315	32.69	-16.95	0.00
400	54.49	-27.63	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

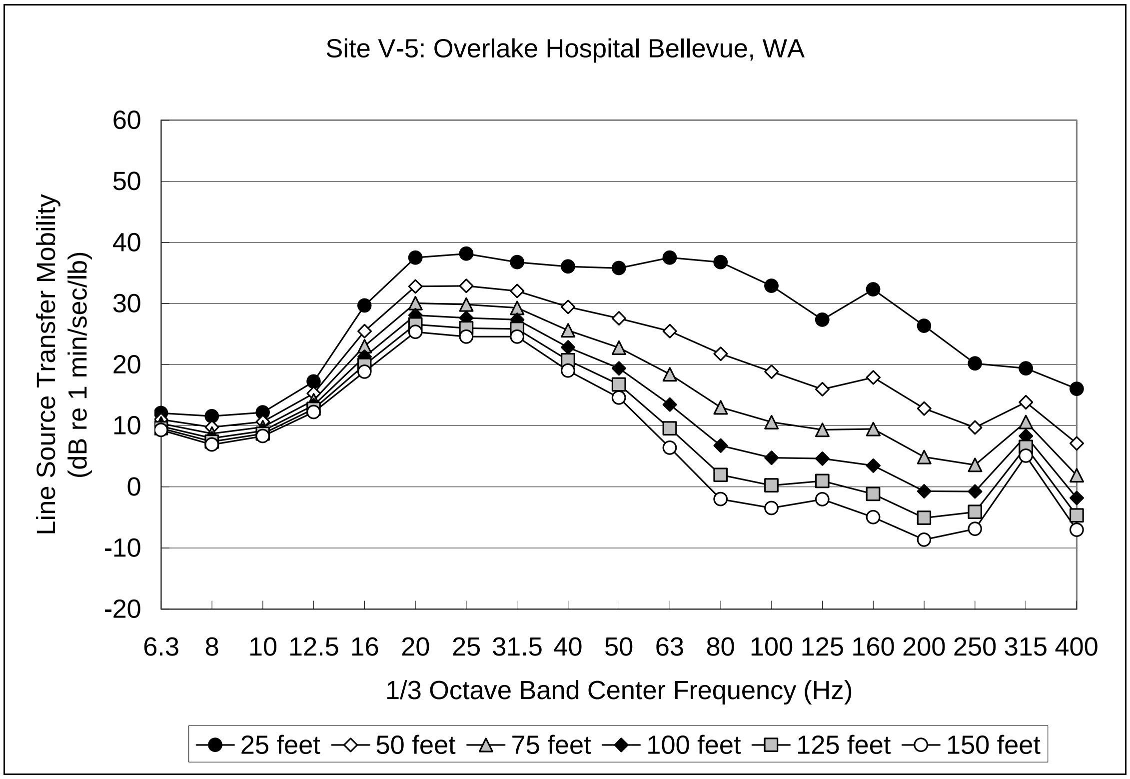


EXHIBIT D-6
Representative Transfer Mobility Functions, Site V-5

TABLE D-6
Line Source Transfer Mobility Coefficients, Site V-5

Frequency (Hz)	A	B	C
6.3	17.01	-3.54	0.00
8	19.90	-5.97	0.00
10	19.11	-4.97	0.00
12.5	26.19	-6.41	0.00
16	49.18	-13.95	0.00
20	59.36	-15.63	0.00
25	62.49	-17.43	0.00
31.5	58.66	-15.66	0.00
40	66.75	-21.95	0.00
50	73.92	-27.27	0.00
63	93.36	-39.96	0.00
80	106.44	-49.84	0.00
100	98.17	-46.70	0.00
125	80.15	-37.77	0.00
160	99.32	-47.92	0.00
200	89.19	-44.96	0.00
250	68.77	-34.76	0.00
315	45.12	-18.40	0.00
400	57.47	-29.64	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

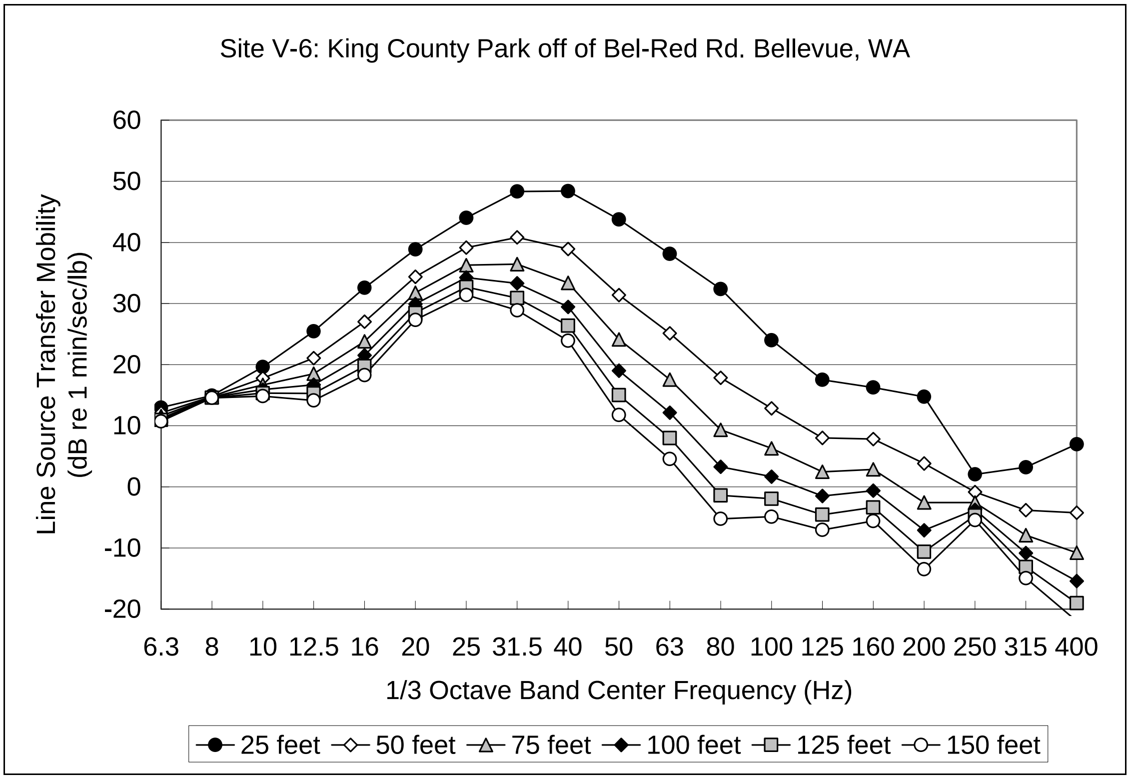


EXHIBIT D7
Representative Transfer Mobility Functions, Site V-6

TABLE D-7
Line Source Transfer Mobility Coefficients, Site V-6

Frequency (Hz)	A	B	C
6.3	17.03	-2.91	0.00
8	15.60	-0.49	0.00
10	28.19	-6.14	0.00
12.5	45.77	-14.53	0.00
16	58.21	-18.35	0.00
20	59.59	-14.84	0.00
25	66.64	-16.19	0.00
31.5	83.24	-24.97	0.00
40	92.46	-31.51	0.00
50	101.24	-41.12	0.00
63	98.45	-43.15	0.00
80	99.99	-48.36	0.00
100	75.87	-37.10	0.00
125	61.66	-31.57	0.00
160	55.51	-28.08	0.00
200	65.42	-36.26	0.00
250	15.46	-9.61	0.00
315	35.82	-23.33	0.00
400	58.98	-37.20	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

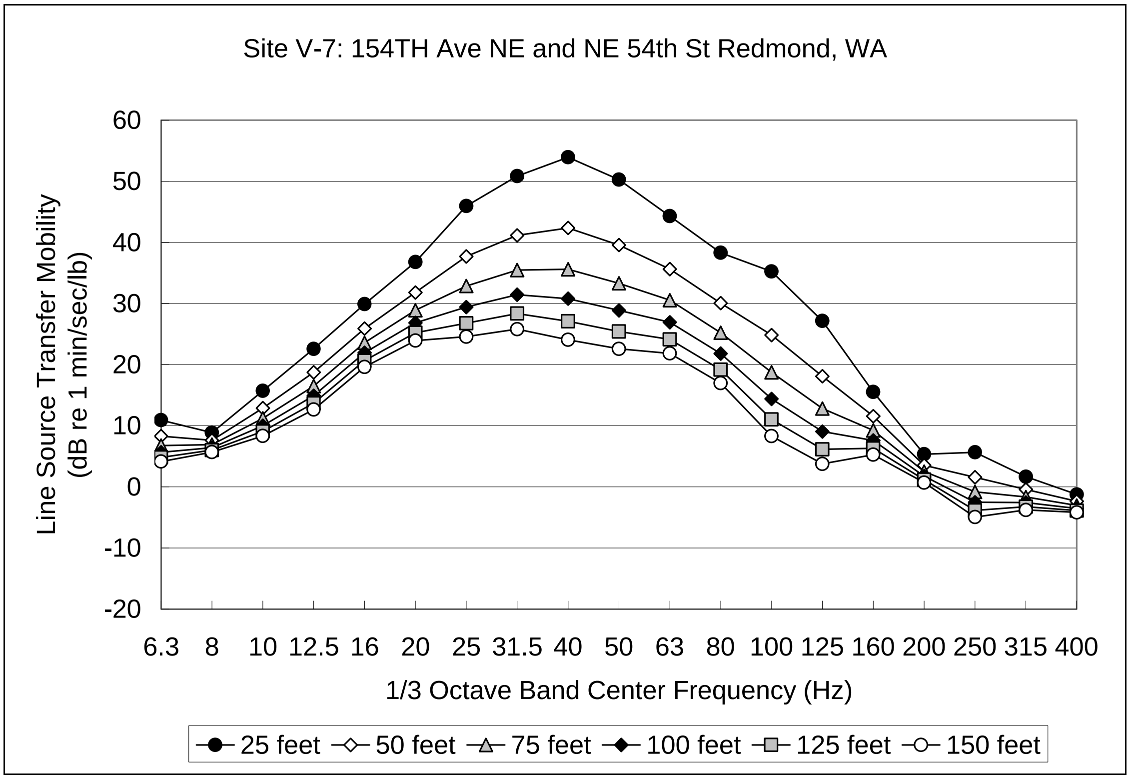


EXHIBIT D-8
Representative Transfer Mobility Functions, Site V-7

TABLE D-8
Line Source Transfer Mobility Coefficients, Site V-7

Frequency (Hz)	A	B	C
6.3	23.05	-8.69	0.00
8	14.62	-4.11	0.00
10	29.02	-9.51	0.00
12.5	40.39	-12.74	0.00
16	48.33	-13.20	0.00
20	59.87	-16.52	0.00
25	84.34	-27.46	0.00
31.5	95.87	-32.20	0.00
40	107.59	-38.39	0.00
50	100.02	-35.58	0.00
63	84.64	-28.85	0.00
80	76.58	-27.39	0.00
100	83.65	-34.62	0.00
125	69.15	-30.05	0.00
160	33.97	-13.19	0.00
200	13.62	-5.94	0.00
250	24.72	-13.63	0.00
315	11.43	-6.99	0.00
400	4.05	-3.78	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1µin/sec/lb/(ft)^1/2

d = Distance in feet

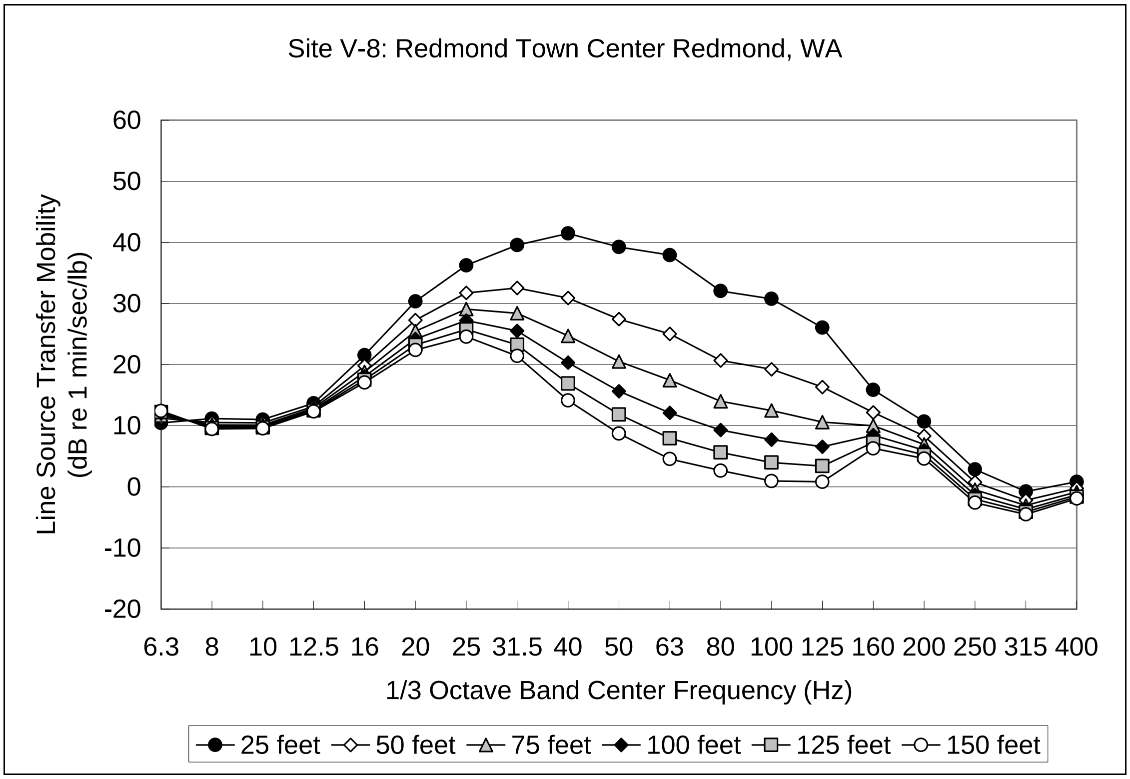


EXHIBIT D-9
Representative Transfer Mobility Functions, Site V-8

TABLE D-9
Line Source Transfer Mobility Coefficients, Site V-8

Frequency (Hz)	A	B	C
6.3	6.97	2.50	0.00
8	14.26	-2.21	0.00
10	13.59	-1.85	0.00
12.5	16.11	-1.73	0.00
16	29.62	-5.77	0.00
20	44.63	-10.22	0.00
25	57.24	-15.01	0.00
31.5	72.14	-23.31	0.00
40	90.61	-35.15	0.00
50	94.03	-39.20	0.00
63	97.87	-42.88	0.00
80	84.86	-37.78	0.00
100	84.28	-38.29	0.00
125	71.42	-32.44	0.00
160	33.12	-12.33	0.00
200	21.59	-7.80	0.00
250	12.66	-7.00	0.00
315	5.94	-4.80	0.00
400	5.78	-3.53	0.00

TM = A + B*log (d) + C*(log (d))^2

Where:

TM = Transfer Mobility in dB re 1μin/sec/lb/(ft)^1/2

d = Distance in feet

Appendix E

Detailed Noise Impact Assessment

TABLE E-1
Segment A Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
1055 to 1065	Sturgus Ave S	SF, MF	12	68	56	63	68	--	--	68
1065 to 1070	20th Ave at S Atlantic St	SF	5	68	56	63	68	--	--	68
1071 to 1075	18th and 19th Ave S + Valentine Place	SF	6	68	53	63	68	--	--	68
1080 to 1085	S Atlantic St by tunnel portal	SF, MF	12	67	49	62	67	--	--	67
1075 to 1085	Judkins Park and Playfield	Park	1	67	59	67	72	--	--	68
1121 to 1130	Tunnel portal to I-90 Bridge (north)	SF	4	67	56	62	67	--	--	67
1121 to 1130	Tunnel portal to I-90 Bridge (south)	SF	3	67	56	62	67	--	--	67
1205 to 1215	Landing on Mercer Island to tunnel	SF	1	65	47 - 53	61	66	--	--	65
1345 to 1355	East end of Mercer Island	SF	2	63	45	60	65	--	--	63

Project stationing from design files
General description of location
[1] Land use: SF = single-family; MF = multi-family; Church, Parks or Schools
[2] Number of structure or MF residential units
[3] Existing L_{dn} for residential land use or L_{eq} for parks, churches and schools
[4] Noise related to the operation of the light rail in L_{dn} for residential land use or L_{eq} for parks, churches and schools
[5] FTA impact criteria from Section 4, Mod = moderate
[6] Number of units exceeding FTA criteria
[7] Total Future noise level in L_{dn} for residential land use or L_{eq} for parks, churches and schools

TABLE E-2

Alternative B1 Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2000	Park	Park	--	62	55	64	69	--	--	63
2005	SE 34th St at 108th Ave	SF	2	66	51	61	67	--	--	66
2007	SE 34th St at 109th Ave	SF	2	66	52	61	67	--	--	66
2010	SE 34th St at 110th - 111th Ave	SF	4	66	52	61	67	--	--	66
2015 to 2025	SE 34th at 113th Ave	SF	3	72	48	65	71	--	--	72
2025	113th Ave SE	SF	2	69	54	64	69	--	--	69
2032	113th Ave SE	SF	3	69	54	64	69	--	--	69
2035	113th Ave SE	SF	3	69	54	64	69	--	--	69
2037	113th Ave SE	SF	1	69	60	64	69	--	--	70
2038	113th Ave SE	SF	1	69	62	64	69	--	--	70
2040 to 2042	Off Bellevue Way	SF	3	69	70	64	69		3	73
2043 to 2045	Off Bellevue Way	SF	2	69	59	64	69	--	--	69
2046	Off Bellevue Way	SF	1	69	57	64	69	--	--	69
2050 to 2054	Near Station	SF	6	69	55	64	69	--	--	69
2055	11th Ave SE	SF	2	67	57	62	67	--	--	67
2056 to 2058	11th Ave SE	SF	3	67	58	62	67	--	--	68
2058	11th Ave SE	SF	1	67	56	62	67	--	--	67
2059 to 2064	11th Ave SE	SF	6	67	58	62	67	--	--	68
2065 to 2070	Near SE 23rd	SF	6	65	55	61	66	--	--	65
2070	Historic House, east of alignment	SF	1	68	57	63	68	--	--	68
2072	109th Ave SE	SF	2	64	54	60	66	--	--	64
2074	110th Ave SE	SF	2	66	56	61	67	--	--	66
2076	111th Ave SE	SF	3	67	57	62	67	--	--	67
2081	MF homes at intersection of 112th	MF	12	69	59	64	69	--	--	69
2082	MF homes at intersection of 112th	MF	12	69	58	64	69	--	--	69
2083	Single home west of 112th Intersection	SF	1	69	56	64	69	--	--	69
2087	SF on 107th Ave SE	SF	1	66	55	61	67	--	--	66
2088	SF on 108th Ave SE	SF	2	66	55	61	67	--	--	66
2089	MF near 105th Ave SE	MF	6	66	55	61	67	--	--	66
2090	MF near 105th Ave SE	MF	6	67	57	62	67	--	--	67
2092	SF second line on 106th Ave SE	SF	2	67	57	62	67	--	--	67
2094 to 2097	residences north of SE 16th St	SF	4	67	57	62	67	--	--	67
2095	Apartment/Condominiums	MF	4	69	58	64	69	--	--	69
2097	Apartment/Condominiums	MF	4	69	58	64	69	--	--	69
2098	Apartment/Condominiums near SE 16th	MF	2	69	59	64	69	--	--	69
2100 to 2104	Two SF on SE 13th St	SF	2	69	59	64	69	--	--	69
2099 to 2101	Two SF eastside of Bellevue Way	SF	2	69	59	64	69	--	--	69
2102	One SF eastside of Bellevue Way	SF	1	68	56	63	68	--	--	68

TABLE E-2
Alternative B1 Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2105	1st Baptist Church	Church	--	69	61	69	74	--	--	70
2108	Pilgrim Lutheran Church	Church	--	69	61	69	74	--	--	70
2104	MF buildings at angle	MF	2	69	58	64	69	--	--	69
2016	MF near church	MF	3	69	59	64	69	--	--	69
2107 to 2111	SF eastside of Bellevue Way	SF	5	69	59	64	69	--	--	69
2115	SF on SE 8th St	SF	1	67	57	62	67	--	--	67
2117 to 2118	SF WS of BW	SF	2	69	59	64	69	--	--	69
2119 to 2122	East side of BW	MF	1	69	59	64	69	--	--	69
2119 to 2122	MF building facing north	MF	1	69	58	64	69	--	--	69
2119 to 2122	MF building facing west	MF	3	69	57	64	69	--	--	69
2000	Park	Park	--	62	55	64	69	--	--	63
2005	SF SE 34th St at 108th Ave	SF	2	66	51	61	67	--	--	66

See Table E-1 for explanation of notes.

TABLE E-3
Alternative B2A Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2000	Park	Park	--	62	55	64	69	--	--	63
2005	SE 34th St at 108th Ave	SF	2	66	56	61	67	--	--	66
2007	SE 34th St at 109th Ave	SF	2	66	57	61	67	--	--	67
2010	SE 34th St at 110th - 111th Ave	SF	4	66	60	61	67	--	--	67
2015	SE 34th at 113th Ave	SF	2	72	55	65	71	--	--	72
2020	SE 34th at 113th Ave	SF	1	72	63	65	71	--	--	73
2025	113th Ave SE	SF	2	0	57	64	69	--	--	69
2032	113th Ave SE	SF	3	69	57	64	69	--	--	69
2035	113th Ave SE	SF	3	69	57	64	69	--	--	69
2037	113th Ave SE	SF	1	69	59	64	69	--	--	69
2038	113th Ave SE	SF	1	69	61	64	69	--	--	70
2038 to 2041	Off Bellevue Way	SF	2	69	57	64	69	--	--	69
2041 to 2043	Off Bellevue Way	SF	2	0	58	64	69	--	--	69
2043	Off Bellevue Way	SF	1	69	60	64	69	--	--	70
2044 to 2051	Near Station	SF	6	69	52	64	69	--	--	69
2052	Transition to at-grade	SF	1	69	59	64	69	--	--	69
2053	Transition to at-grade	SF	1	69	56	64	69	--	--	69
2054 to 2058	11th Ave SE	SF	6	68	56	63	68	--	--	68
2058 to 2063	11th Ave SE	SF	4	68	56	63	68	--	--	68
2063 to 2066	Near SE 23rd	SF	4	66	55	61	67	--	--	66
2068	Historic House, east of alignment	SF	1	69	58	64	69	--	--	69
2068	109th Ave SE	SF	1	68	57	63	68	--	--	68
2072 to 2074	110th Ave SE	SF	3	68	57	63	68	--	--	68
2076	111th Ave SE	SF	1	68	56	63	68	--	--	68
2079	MF homes at intersection of 112th	MF	6	0	57	64	69	--	--	69

TABLE E-3
Alternative B2A Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2080 to 2087	SF homes on ridge	SF	4	64	55	60	66	--	--	65
2092	MF units near SE 15th	SF	2	67	57	62	67	--	--	67
2095	SF on 112th SE 15	SF	1	67	58	62	67	--	--	68
2097 to 2100	MF units north of SE 15	MF	2	67	57	62	67	--	--	67
2097 to 2100	MF units north of SE 15	MF	8	66	55	61	67	--	--	66
2102	MF units facing NS	MF	1	66	55	61	67	--	--	66
2103 to 2105	cul-de sac south of SE8th	SF	3	67	58	62	67	--	--	68
2106	111th place	SF	1	66	51	61	67	--	--	66
2107 to 2111	111th place	SF	6	66	51	61	67	--	--	66
2112	111th place	SF	1	67	59	62	67	--	--	68

See Table E-1 for explanation of notes.

TABLE E-4
Alternative B2E Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2000	Park	Park	--	62	55	64	69	--	--	63
2005	SE 34th St at 108th Ave	SF	2	66	56	61	67	--	--	66
2007	SE 34th St at 109th Ave	SF	2	66	57	61	67	--	--	67
2010	SE 34th St at 110th - 111th Ave	SF	4	66	60	61	67	--	--	67
2015	SE 34th at 113th Ave	SF	2	72	55	65	71	--	--	72
2020	SE 34th at 113th Ave	SF	1	72	63	65	71	--	--	73
2025	113th Ave SE	SF	2	0	57	64	69	--	--	69
2032	113th Ave SE	SF	3	69	57	64	69	--	--	69
2035	113th Ave SE	SF	3	69	57	64	69	--	--	69
2037	113th Ave SE	SF	1	69	59	64	69	--	--	69
2038	113th Ave SE	SF	1	69	61	64	69	--	--	70
2038 to 2041	Off Bellevue Way	SF	2	69	57	64	69	--	--	69
2041 to 2043	Off Bellevue Way	SF	2	0	58	64	69	--	--	69
2043	Off Bellevue Way	SF	1	69	60	64	69	--	--	70
2044 to 2051	Near Station	SF	6	69	52	64	69	--	--	69
2052	Transition to at-grade	SF	1	69	59	64	69	--	--	69
2053	Transition to at-grade	SF	1	69	56	64	69	--	--	69
2054 to 2058	11th Ave SE	SF	6	68	56	63	68	--	--	68
2058 to 2063	11th Ave SE	SF	4	68	56	63	68	--	--	68
2063 to 2066	Near SE 23rd	SF	4	66	55	61	67	--	--	66
2068	Historic House, east of alignment	SF	1	69	58	64	69	--	--	69
2068	109th Ave SE	SF	1	68	57	63	68	--	--	68
2072 to 2074	110th Ave SE	SF	3	68	57	63	68	--	--	68
2076	111th Ave SE	SF	1	68	56	63	68	--	--	68
2079	MF homes at intersection of 112th	MF	6	0	57	64	69	--	--	69
2080 to 2087	SF homes on ridge	SF	4	64	55	60	66	--	--	65
2092	MF units near SE 15th	SF	2	67	57	62	67	--	--	67
2095	SF on 112th SE 15	SF	1	67	58	62	67	--	--	68
2097 to 2100	MF units north of SE 15	MF	2	67	57	62	67	--	--	67
2097 to 2100	MF units north of SE 15	MF	8	66	55	61	67	--	--	66
2102	MF units facing NS	MF	1	66	55	61	67	--	--	66
2103 to 2105	cul-de sac south of SE8th	SF	3	67	58	62	67	--	--	68
2106	111th place	SF	1	66	51	61	67	--	--	66
2107 to 2111	111th place	SF	6	66	51	61	67	--	--	66
2112	111th place	SF	1	67	59	62	67	--	--	68

See Table E-1 for explanation of notes.

TABLE E-5
Alternative B3 Light Rail Noise Projections

Station[1]	Area Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2000	Park	Park	--	62	55	64	69	--	--	63
2005	SE 34th St at 108th Ave	SF	2	66	56	61	67	--	--	66
2007+50	SE 34th St at 109th Ave	SF	2	66	57	61	67	--	--	67
2010	SE 34th St at 110th - 111th Ave	SF	4	66	60	61	67	--	--	67
2015	SE 34th at 113th Ave	SF	2	72	55	65	71	--	--	72
2020	SE 34th at 113th Ave	SF	1	72	63	65	71	--	--	73
2025	113th Ave SE	SF	2	69	57	64	69	--	--	69
2032	113th Ave SE	SF	3	69	57	64	69	--	--	69
2035	113th Ave SE	SF	3	69	57	64	69	--	--	69
2037	113th Ave SE	SF	1	69	59	64	69	--	--	69
2038	113th Ave SE	SF	1	69	61	64	69	--	--	70
2038 to 2041	off Bell Way	SF	2	69	57	64	69	--	--	69
2041 to 2043	Off Bell Way	SF	2	69	58	64	69	--	--	69
2043	off Bell Way	SF	1	69	60	64	69	--	--	70
2044 to 2051	Station	SF	6	69	52	64	69	--	--	69
2052	transition	SF	1	69	59	64	69	--	--	69
2053	transition	SF	1	69	56	64	69	--	--	69
2054 to 2058	at-grade	SF	6	68	56	63	68	--	--	68
2058 to 2063	0	SF	4	68	56	63	68	--	--	68
2063 to 2066	0	SF	4	66	55	61	67	--	--	66
2068	Historic	SF	1	69	58	64	69	--	--	69
2068	0	SF	1	68	57	63	68	--	--	68
2072 to 2074		SF	3	68	57	63	68	--	--	68
2076	Lone house at intersection	SF	1	68	56	63	68	--	--	68
2079	MF apartment buildings	MF	6	69	57	64	69	--	--	69
2080 to 2087	SF homes on ridge	SF	4	64	55	60	66	--	--	65
2092	MF units	SF	2	67	57	62	67	--	--	67
2095	lone unit on 112th NE SE 15	SF	1	67	58	62	67	--	--	68
2097 to 2100	MF units north of SE 15	MF	2	67	57	62	67	--	--	67
2097 to 2100	MF units north of SE 15	MF	8	66	55	61	67	--	--	66
2102	MF units facing NS	MF	1	66	55	61	67	--	--	66
2103 to 2105	cull-de sac south of SE8th	SF	3	67	58	62	67	--	--	67
2106	111th place	SF	1	66	51	61	67	--	--	66
2107 to 2111	111th place	SF	3	66	51	61	67	--	--	66

See Table E-1 for explanation of notes.

TABLE E-6
Alternative B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
2000	Park	Park	--	62	55	64	69	--	--	63
2005	SE 34th St at 108th Ave	SF	2	66	54	61	67	--	--	66
2007+50	SE 34th St at 109th Ave	SF	2	66	55	61	67	--	--	66
2010	SE 34th St at 110th - 111th Ave	SF	4	66	55	61	67	--	--	66
2015	SE 34th at 113th Ave	SF	2	72	57	65	71	--	--	72
2020	SE 34th at 113th Ave	SF	1	72	58	65	71	--	--	72
2021	113th Ave SE	SF	2	69	58	64	69	--	--	69
2029 to 2063	MF on BNFS	MF	36	64	67	60	66		36	69
2064	Angled buildings	MF	12	64	59	60	66	--	--	65
2068 to 2069+50	0	MF	11	64	60	60	66	11	--	66
2070 to 2073	Set back buildings	MF	48	64	58	60	66	--	--	65
2074 to 2075	0	MF	24	64	61	60	66	24	--	66
2076 to 2079	Northern three building	MF	48	64	58	60	66	--	--	65
2100	0	MF	9	60	59	58	63	9	--	62
2101	0	MF	9	60	59	58	63	9	--	62
2106	0	MF	12	60	57	58	63	--	--	62
2104	0	MF	3	60	64	58	63		3	65
2105+50	0	MF	6	60	59	58	63	6	--	62

See Table E-1 for explanation of notes.

TABLE E-7
Alternative C1T Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3002	Two MF L shaped building	MF	6	69	53	64	69	--	--	69
3002	Two MF L shaped building	MF	24	68	51	63	68	--	--	68
3005	MF building eastside of street	MF	12	69	51	64	69	--	--	69
3006	MF on west side of BW	MF	12	66	49	61	67	--	--	66
3111	MF units on Lake Bellevue	MF	18	60	59	58	63	18	--	63

See Table E-1 for explanation of notes.

TABLE E-8
Alternative C2T from B2E Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3005	Tennis courts	0	0	69	73	64	69	--	--	75
3004 to 3005	Hotel Rooms	Hotel	18	69	68	64	69	18	--	71
3007	Homes along the Westside of 112	SF	2	70	72	64	69	--	3	74
3009	MF units	MF	1	70	72	64	69	--	3	74
3008 to 3015	MF units - all about the same dist	MF	7	70	61	64	69	--	--	70
3008 to 3015	MF units - second dist homes	MF	6	70	60	64	69	--	--	70
3016 to 3019	MF units near main	MF	6	70	60	64	69	--	--	70
3075	Meydenbauer Center	Concert Hall	1	68	62	63	68	--	--	69
3111	MF units on Lake Bellevue	MF	18	60	59	58	63	18	--	63

See Table E-1 for explanation of notes.

TABLE E-9
Alternative C2T from B3 or C2T from B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3010	Hilton Hotel pool	MF	1	74	62	65	72	--	--	74
3010	Hilton Hotel north end	MF	12	74	65	65	72	4	--	75
3075	Meydenbauer Center	Concert Hall	1	68	62	63	68	--	--	69
3111	MF units on Lake Bellevue	MF	18	60	59	58	63	18	--	63

See Table E-1 for explanation of notes.

TABLE E-10
Alternative C2T from B2A Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3075	Meydenbauer Center	Concert Hall	1	68	62	63	68	--	--	69
3111	MF units on Lake Bellevue	MF	18	60	59	58	63	18	--	63

See Table E-1 for explanation of notes.

TABLE E-11
Alternative C3T from B2A Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3080+90	Exit from Tunnel on 12th	SF	1	62	53	59	64	--	--	63
3082+50	Transition to elevated	SF	1	62	57	59	64	--	--	63
3083 to 3086	Transition to elevated	SF	2	62	57	59	64	--	--	63
3086+50	Elevated	SF	1	64	60	60	66	--	--	65
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-12
Alternative C3T from B2E Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3005	Tennis courts			69	73	64	69	--	--	75
3004 to 3005	Hotel Rooms	Hotel	18	69	68	64	69	18	--	71
3007	Homes along the Westside of 112	SF	3	70	71	64	69	--	3	73
3009	MY units	MF	3	70	71	64	69	--	3	73
3008 to 3015	MF units - all about the same dist	MF	7	70	61	64	69	--	--	70
3008 to 3015	MF units - second dist homes	MF	6	70	60	64	69	--	--	70
3016 to 3019	MF units near main	MF	6	70	60	64	69	--	--	70

See Table E-1 for explanation of notes.

TABLE E-13
Alternative C3T from B3 or B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3010	Hilton Hotel pool	MF	1	74	62	65	72	--	--	74
3010	Hilton Hotel north end	MF	12	74	65	65	72	4	--	75

See Table E-1 for explanation of notes.

TABLE E-14
Alternative C4A from B2A Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3079 to 3082	Tennis courts	0	1	69	58	64	69	--	--	69
3079 to 3082	Hotel far bldg	Hotel	36	69	49	64	69	--	--	69
3079 to 3082	Hotel near building	Hotel	26	70	56	64	69	--	--	70
3081	Homes along the Westside of 112	SF	2	70	59	64	69	--	--	70
3083	MY units	MF	1	70	60	64	69	--	--	70
3083 to 3090	MF units - all about the same dist	MF	8	68	61	63	68	--	--	69
3084 to 3090	MF units - second dist homes	MF	12	70	62	64	69	--	--	71
3090 to 3093	MF units near main and switch	MF	12	70	68	64	69	12	--	72
3094	Last SF near main	SF	1	70	57	64	69	--	--	70
3097	homes on 11th Ave SE	SF	2	62	54	59	64	--	--	63
3101	homes on 11th Ave SE	SF	1	62	57	59	64	--	--	63
3103	homes on 110th Pl and Ave	SF	2	62	55	59	64	--	--	63
3105	Homes on 109th curve	SF	3	62	54	59	64	--	--	63
3103 to 3133	Westside general	SF	1	67	58	62	67	--	--	68
3103 to 3133	Eastside general	SF	1	67	56	62	67	--	--	67
3109 to 3140	Westside general	SF	1	67	58	62	67	--	--	68
3109 to 3141	Eastside general Condos on NE 2nd Pl	SF	1	67	56	62	67	--	--	67
3140	Bellevue Library	0	1	66	60	61	67	--	--	67
3138	MF homes at 111 & NE 190th	MF	36	66	57	61	67	--	--	66
3142	MF homes near 112th on 10th	MF	36	66	57	61	67	--	--	67
3140 to 3148	MF (?) homes on 108 10th to 12th	MF	1	66	57	61	67	--	--	67
3152	SF home north of 12 at 108th	SF	1	64	56	60	66	--	--	65
3152	SF home north of 12 at 108th	SF	1	66	60	61	67	--	--	67
3145	SF homes north of 12th	SF	1	62	56	59	64	--	--	63
3145 to 3149	SF homes north of 12th	SF	3	62	54	59	64	--	--	63
3150	SF home on 112th at 12th	SF	1	66	57	61	67	--	--	66
3095	Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-15
Alternative C4A from B2E Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3079 to 3083	Hotel Rooms	Hotel	36	69	58	64	69	--	--	69
3082	Hotel Rooms	Hotel	26	70	60	64	69	--	--	70
3082	Homes along the Westside of 112	SF	2	70	61	64	69	--	--	70
3085	MF units	MF	1	70	61	64	69	--	--	70
3085 to 3089	MF units - all about the same dist	MF	7	70	61	64	69	--	--	70
3085 to 3089	MF units - second dist homes	MF	6	70	60	64	69	--	--	70
3016 to 3019	MF units near main	MF	6	70	70	64	69		6	73
3094	Last SF unit near main	SF	1	70	57	64	69	--	--	70
3097	homes on 11th Ave SE	SF	2	62	54	59	64	--	--	63
3101	homes on 11th Ave SE	SF	1	62	57	59	64	--	--	63
3103	homes on 110th Pl and Ave	SF	2	62	55	59	64	--	--	63
3105	Homes on 109th curve	SF	3	62	54	59	64	--	--	63
3103 to 3133	Westside general	SF	1	67	58	62	67	--	--	68
3103 to 3133	Eastside general	SF	1	67	56	62	67	--	--	67
3109 to 3140	Westside general	SF	1	67	58	62	67	--	--	68
3109 to 3141	Eastside general Condos on NE 2nd Pl	SF	1	67	56	62	67	--	--	67
3140	Bellevue Library	0	1	66	60	61	67	--	--	67
3138	MF homes at 111 & NE 190th	MF	36	66	57	61	67	--	--	66
3142	MF homes near 112th on 10th	MF	36	66	57	61	67	--	--	67
3140 to 3148	MF (?) homes on 108 10th to 12th	MF	1	66	57	61	67	--	--	67
3152	SF home north of 12 at 108th	SF	1	64	56	60	66	--	--	65
3152	SF home north of 12 at 108th	SF	1	66	60	61	67	--	--	67
3145	SF homes north of 12th	SF	1	62	56	59	64	--	--	63
3145 to 3149	SF homes north of 12th	SF	3	62	54	59	64	--	--	63
3150	SF home on 112th at 12th	SF	1	66	57	61	67	--	--	66
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-16
Alternative C4A from B3 or B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3085	Hilton Hotel pool	MF	1	74	62	65	72	--	--	74
3087	Hilton Hotel north end	MF	12	74	65	65	72	4	--	75
3097	homes on 11th Ave SE	SF	2	62	54	59	64	--	--	63
3101	homes on 11th Ave SE	SF	1	62	57	59	64	--	--	63
3103	homes on 110th Pl and Ave	SF	2	62	55	59	64	--	--	63
3105	Homes on 109th curve	SF	3	62	54	59	64	--	--	63
3103 to 3133	Westside general	SF	1	67	58	62	67	--	--	68
3103 to 3133	Eastside general	SF	1	67	56	62	67	--	--	67
3109 to 3140	Westside general	SF	1	67	58	62	67	--	--	68
3109 to 3141	Eastside general Condos on NE 2nd Pl	SF	1	67	56	62	67	--	--	67
3140	Bellevue Library	0	1	66	60	61	67	--	--	67
3138	MF homes at 111 & NE 190th	MF	36	66	57	61	67	--	--	66
3142	MF homes near 112th on 10th	MF	36	66	57	61	67	--	--	67
3140 to 3148	MF (?) homes on 108 10th to 12th	MF	1	66	57	61	67	--	--	67
3152	SF home north of 12 at 108th	SF	1	64	56	60	66	--	--	65
3152	SF home north of 12 at 108th	SF	1	66	60	61	67	--	--	67
3145	SF homes north of 12th	SF	1	62	56	59	64	--	--	63
3145 to 3149	SF homes north of 12th	SF	3	62	54	59	64	--	--	63
3150	SF home on 112th at 12th	SF	1	66	57	61	67	--	--	66
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-17
Alternative C7E from B2A Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3079 to 3082	Tennis courts	0	1	69	58	64	69	--	--	69
3079 to 3082	Hotel far bldg	MF	36	69	49	64	69	--	--	69
3079 to 3082	Hotel near building	MF	26	70	56	64	69	--	--	70
3081	Homes along the Westside of 112	SF	2	70	59	64	69	--	--	70
3083	MY units	MF	1	70	60	64	69	--	--	70
3083 to 3090	MF units - all about the same dist	MF	8	68	61	63	68	--	--	69
3084 to 3090	MF units - second dist homes	MF	12	70	62	64	69	--	--	71
3090 to 3093	MF units near main and switch	MF	12	70	71	64	69		12	73
3094	Last SF near main	SF	1	70	60	64	69	--	--	70
3095	Hotel	MF	36	70	61	64	69	--	--	70
3102	Hotel	MF	1	70	58	64	69	--	--	70
3104	MF Units	MF	48	70	60	64	69	--	--	70
3075	Meydenbauer Center	Concert Hall	1	70	62	64	69	--	--	71
3131	Hotel	MF	48	68	63	63	68	--	--	69
3135	Condos	MF	48	68	62	63	68	--	--	69

TABLE E-17
Alternative C7E from B2A Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3138	SF at 12 and 112	SF	1	68	58	63	68	--	--	68
3138 Park	0	0	1	68	57	63	68	--	--	68
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-18
Alternative C7E from B2E Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3079 to 3082	Tennis courts	0	0	69	63	64	69	--	--	70
3079 to 3082	Hotel Rooms	Hotel	36	69	58	64	69	--	--	69
3079 to 3082	Hotel Rooms	Hotel	26	70	60	64	69	--	--	70
3081	Homes along the Westside of 112	SF	2	70	61	64	69	--	--	70
3083	MF units	MF	1	70	61	64	69	--	--	70
3083 to 3090	MF units - all about the same dist	MF	7	70	61	64	69	--	--	70
3084 to 3090	MF units - second dist homes	MF	6	70	60	64	69	--	--	70
3090 to 3093	MF units near main	MF	6	70	70	64	69		6	73
3094	Last SF near main	SF	1	70	60	64	69	--	--	70
3095	Hotel	MF	36	70	61	64	69	--	--	70
3102	Hotel	MF	1	70	58	64	69	--	--	70
3104	MF Units	MF	48	70	60	64	69	--	--	70
3075	Meydenbauer Center	Concert Hall	1	70	62	64	69	--	--	71
3131	Hotel	MF	48	68	63	63	68	--	--	69
3135	Condos	MF	48	68	62	63	68	--	--	69
3138	SF at 12 and 112	SF	1	68	58	63	68	--	--	68
3138 Park	0	0	1	68	57	63	68	--	--	68
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-19
Alternative C7E from B3 or B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3085	Hilton Hotel pool	MF	1	74	62	65	72	--	--	74
3087	Hilton Hotel north end	MF	12	74	65	65	72	4	--	75
3102	Hotel	MF	1	70	58	64	69	--	--	70
3104	MF Units	MF	48	70	60	64	69	--	--	70
3075	Meydenbauer Center	Concert Hall	1	70	62	64	69	--	--	71
3131	Hotel	MF	48	68	63	63	68	--	--	69
3135	Condos	MF	48	68	62	63	68	--	--	69
3138	SF at 12 and 112	SF	1	68	58	63	68	--	--	68

TABLE E-19
Alternative C7E from B3 or B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3138 Park	0	0	1	68	57	63	68	--	--	68
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-20
Alternative C8E from B3 or B7 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
3085	Hilton Hotel pool	MF	1	74	62	65	72	--	--	74
3087	Hilton Hotel north end	MF	12	74	65	65	72	4	--	75
3102	Hotel	MF	1	70	58	64	69	--	--	70
3105	MF	MF	68	70	61	64	69	--	--	71
3112	MF	MF	26	66	60	61	67	--	--	67
3133	MF	MF	18	66	63	61	67	18	--	68
3137	MF	MF	20	66	63	61	67	20	--	68
3140	MF	MF	36	66	60	61	67	--	--	67
3141	MF	MF	42	66	64	61	67	42	--	68
3144	SF	SF	1	64	64	60	66	1	--	67
3146	SF	SF	2	62	62	59	64	2	--	65
3095	Station to Hospital	Hospital	1	72	52	65	71	--	--	72
3098	Hospital	Hospital	1	68	57	63	68	--	--	68

See Table E-1 for explanation of notes.

TABLE E-21
Alternative D5 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
--	Hospital	Hospital	1	68	61	63	68	--	--	62
--	MF	MF	10	68	65	65	71	10		73

See Table E-1 for explanation of notes.

TABLE E-22

Alternative E1 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
5100	Condos on 156th Pl	MF	20	63	62	60	66	20	--	67
5100	Condos on 156th Pl angled building	MF	6	64	63	60	66	6	--	67
5114	Hotel	MF	200	66	57	61	67	--	--	67

See Table E-1 for explanation of notes.

TABLE E-23

Alternative E4 Light Rail Noise Projections

Station[1]	Description[2]	Land Use[3]	Units[4]	Existing[5] L_{dn} (L_{eq})	Project[6] L_{dn} (L_{eq})	Impact Criteria[7]		Project Impacts[8]		Total Noise L_{dn} (L_{eq})
						Mod	Severe	Mod	Severe	
5095	Leary way	0	0	64	57	60	66	--	--	65
5115	Hotel	MF	200	64	57	60	66	--	--	65

See Table E-1 for explanation of notes.

TABLE E-24
Modeling Results for Traffic Noise Impacts, Bellevue Way Alternative (B1)

Receiver	Dwellings	Criteria	Existing	Impacts	No Build	Change from Existing	Impacts	Build	Change from Existing	Impacts	Change from No-Build	Notes
R1	3	66	66	3	68	2	3	69	3	3	1	Single-family
R2	3	66	59	--	61	2	--	62	3	--	1	Single-family
R3	3	66	58	--	60	2	--	60	2	--	0	Single-family
R4	5	66	65	--	67	2	5	68	3	5	1	Single-family
R5	6	66	58	--	60	2	--	60	2	--	0	Single-family
R6	2	66	61	--	63	2	--	63	2	--	0	Single-family
R7	5	66	66	5	68	2	5	68	2	5	0	Single-family
R8	8	66	66	8	68	2	8	72	6	8	4	Winters House
R9	4	66	57	--	59	2	--	57	0	--	-2	Park Trail (25*.17)
R10	6	66	60	--	62	2	--	63	3	--	1	Single-family
R11	0	66	66	0	68	2	0	71	5	0	3	Single-family
R12	1	66	65	--	67	2	1	65	0		-2	Single-family
R13	4	66	61	--	63	2	--	62	1	--	-1	Park Trail (25*.17)
R14	4	66	67	4	69	2	4	72	5	4	3	Single-family
R15	6	66	62	--	64	2	--	64	2	--	0	Single-family
R16	3	66	70	3	72	2	3	74	4	3	2	Single-family
R17	8	66	62	--	64	2	--	63	1	--	-1	Single-family
R18	16	66	63	--	66	3	16	68	5	16	2	Multi-family
R19	0	67	64	--	67	3	--	67	3	--	0	Recreation area
R20	6	66	60	--	62	2	--	62	2	--	0	Single-family
R21	6	66	61	--	63	2	--	64	3	--	1	Single-family
R22	5	66	60	--	63	3	--	64	4	--	1	Single-family
R23	6	66	65	--	67	2	6	66	1	6	-1	Multi-family
R24	4	66	61	--	63	2	--	64	3	--	1	Single-family
R25	4	66	60	--	62	2	--	61	1	--	-1	Multi-family
R26	3	66	63	--	65	2	--	67	4	3	2	Single-family
R27	11	66	66	11	68	2	11	70	4	11	2	Single-family (Front yards)
R28	12	66	60	--	62	2	--	63	3	--	1	Single-family (Back yards)
R29	6	66	59	--	61	2	--	60	1	--	-1	Single-family
R30	2	66	60	--	62	2	--	63	3	--	1	Single-family
R31	18	66	66	18	69	3	18	68	2	18	-1	Multi-family

TABLE E-25
Modeling Results for Traffic Noise Impacts, 112th SE At-Grade (B2A) and 112th SE Bypass (B3) Alternatives

Receiver	Dwellings	Criteria	Existing	Impacts	No Build	Change from Existing	Impacts	Build	Change from Existing	Impacts	Change from No-Build	Notes
R-8	8	66	66	8	68	2	8	72	6	8	4	Single-family
R-9	4	66	57	--	59	2	--	58	1	--	-1	Winters House
R-10	6	66	60	--	62	2	--	62	2	--	0	Single-family
R-11	5	66	66	5	68	2	5	68	2	5	0	Single-family
R-12	0	71	65	--	67	2	--	66	1	--	-1	Commercial
R-13	4	66	61	--	63	2	--	62	1	--	-1	Park Trail (25*.17)
R-14	4	66	67	4	69	2	4	70	3	4	1	Single-family
R-15	6	66	62	--	64	2	--	64	2	--	0	Single-family
R-16	3	66	70	3	72	2	3	72	2	3	0	Single-family
R-17	8	66	62	--	64	2	--	63	1	--	-1	Single-family

TABLE E-26
Modeling Results for Traffic Noise Impacts, Bellevue Way Tunnel Alternative (C1T)

Receiver	Dwellings	Criteria	Existing	Impacts	No Build	Change from Existing	Impacts	Build	Change from Existing	Impacts	Change from No-Build	Notes
R32	21	66	67	21	69	2	21	67	0	21	-2	Multi-family
R33	6	66	61	--	63	2	--	63	2	--	0	Multi-family

Appendix F

Supplemental Noise Analyses

Prepared for:	Jodi Ketelsen / CH2M HILL
Prepared by:	Michael A. Minor
Date:	Monday, November 10, 2008
Subject:	Station Noise Levels and Potential Noise Mitigation
Project:	Sound Transit East Link Station Analysis

This memorandum provides a summary of noise levels at existing and proposed East Link light rail stations. As a point of comparison, noise measurements were taken at:

- SR 520 Evergreen Road Flyer Stop (readings taken near the 84th Avenue off-ramp)
- SR 520 Montlake Flyer Stop

Where appropriate, noise abatement measures are discussed. The following stations were examined:

- Rainier Avenue light rail station (I-90 center roadway at the 23rd Avenue over crossing)
- Mercer Island light rail station (I-90 between 77th and 80th Avenues)
- Ashwood/Hospital light rail station (NE 12th Street on overpass above I-405)

Analysis Period

Traffic noise levels on I-90, I-405, and SR-520 are all loudest during mid-day hours of 11:00 a.m. to 3:00 p.m. This is due to the higher speeds and level of truck traffic during daytime hours. Peak commute traffic noise levels on these same highways are typically lower (by 2 to 3 dBA) due to reduced speeds associated with congested highways. Based on these factors, the maximum traffic noise levels during daytime hours were used in the analysis. The analysis also assumes the worst-case, 15-minute headways for the maximum time a person would spend at a platform.

Station Noise Level Guidelines

There are no federal standards for noise exposure on transit passengers at stations due to traffic noise. Sound Transit has established a general design criteria goal of 72 dBA L_{eq} for noise from exterior sources at station platforms. The National Institute for Occupations Safety and Health (NIOSHA) standard for workplace noise exposure is 85 dBA for up to 8 hours, or 100 dBA for 15 minutes (NIOSHA Publication No. 98-126, Occupational Noise Exposure, June 1998). The EPA states that communication at close proximity (2 to 4 feet) can be understood even with ambient noise levels of 72 to 78 dBA ("Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA/ONAC 550/9-74-004, March, 1974).

Noise measurements were taken at existing bus flyer stops on SR 520. Noise level for the SR 520 Evergreen Road Flyer Stop are derived from readings taken near the 84th Avenue off-ramp as part of the quiet pavement study. The measurements were taken at 75 feet from SR 520, which is close to the distance for the Evergreen Flyer stop. Noise levels at this distance before the quiet pavement was installed ranged from 72 to 75 dBA L_{eq} during daytime hours (7 a.m. to 7 p.m.), reducing to 64 to 66 dBA L_{eq} after midnight. Current noise levels are 4 to 5 dBA lower then this, but in recent measurements, the upper-level hourly L_{eq} noise levels are consistently above 70 dBA L_{eq} at this location.

Noise reading were also taken near the waiting area of the SR 520 Montlake Flyer Stop. Noise levels varied with traffic flow, and the 1-second L_{eq} ranged from 76 to 89 dBA. The typical peak traffic noise

level for this station is 81.1 dBA L_{eq}. This shows that the transit riders are currently exposed to high noise levels at transit stops.

There is a potential that, on some station platforms, reducing traffic noise levels to Sound Transit's 72 dBA design goal may not be feasible or reasonable. As stated, it is unlikely that a person would ever spend more than 15 minutes at a station platform. Due to the short period of waiting at platforms, and existing bus-flyer stop noise levels in the region, Sound Transit will use the 78 dBA 15-minute L_{eq} platforms noise level goal for designing stations within or above freeway, where reasonable and feasible.

Noise Measurements

Noise readings were taken at several existing and proposed stations. The measurements were taken in accordance with the American National Standards Institute (ANSI) procedures for community noise measurements. The equipment used for noise monitoring was a Bruel & Kjaer Type 2238 Sound Level Meter. The meter was calibrated prior to and after the measurement period using a Bruel & Kjaer Type 4231 Sound Level Calibrator. Calibration varied by less than 0.1 dB during the measurement periods. Complete system calibration is performed on an annual basis by Bruel & Kjaer Instruments. System calibration is traceable to the National Institute of Standards and Testing (NIST). The system meets or exceeds the requirements for an ANSI Type 1 noise measurement system.

Rainier Avenue Light Rail Station

The Rainier Avenue light rail station would be located along the center of I-90 in a retained cut in the center roadway just west of the Mount Baker Tunnels. This location has large retaining walls along the both sides the highway, resulting in a substantial level of reflected traffic noise. Existing noise levels were measured using a microphone on a 40 foot extension cable dropped over the edge of the 23rd Avenue overpass. The measurement was taken around 11:00 am when traffic on the revisable lanes were changing direction, and only one pass-by was recorded on the reversible lanes. This would most closely resemble the East Link Project scenario. The 15 minute L_{eq} for the existing conditions was measured at 86.3 dBA L_{eq}.

Mercer Island Light Rail Station

The Mercer Island Station would be located along the center of I-90 in a deep retained cut between 77th Avenue and 80th Avenue on Mercer Island. This location has 20- to 25-foot-high retaining walls along each side of the highway, resulting in a substantial level of reflected traffic noise. Existing noise levels were measured at the Mercer Island Station using a microphone on a 40-foot extension cable dropped over the edge of the77th Avenue overpass. This location is shown in Table 1 as R1/M1, and this measurement was used to calibrate the model used to project noise levels at other points within the proposed station. This location was not used to determine the effects traffic noise on passengers as this is merely a pass-through area to the station platform.

Two 10-minute measurements were taken, with the first having a L_{eq} of 86 dBA and the second having an L_{eq} of 88 dBA. For transit stations near major highways, a short-term Leq measurement of 10 minutes is typically long enough to provide an accurate reading of the noise exposure. This is due to the relatively steady noise from passing vehicles on major highways. Measurements at the Mercer Island and NE 12th Street stations provided verification of this, as the running L_{eq} stabilized after only 2 minutes of measurements and varied by less than 1 dBA after 5 minutes, even during heavy truck pass-bys where 1-second L_{eq} sound levels exceeded 92 dBA.

To illustrate this, the 1-second L_{eq} noise levels along with a running-energy average Leq at 10-second intervals was derived and plotted. Figure 1 shows the results of the analysis. The orange dashed lines are the 1-second L_{eq} readings and the black squares are the running-energy average for the measurement period to that point. The plot shows that after approximately 2 minutes, the energy average noise levels remain constant at 88 dBA (+0.3/ -0.5 dBA) for the remainder of the measurement session.

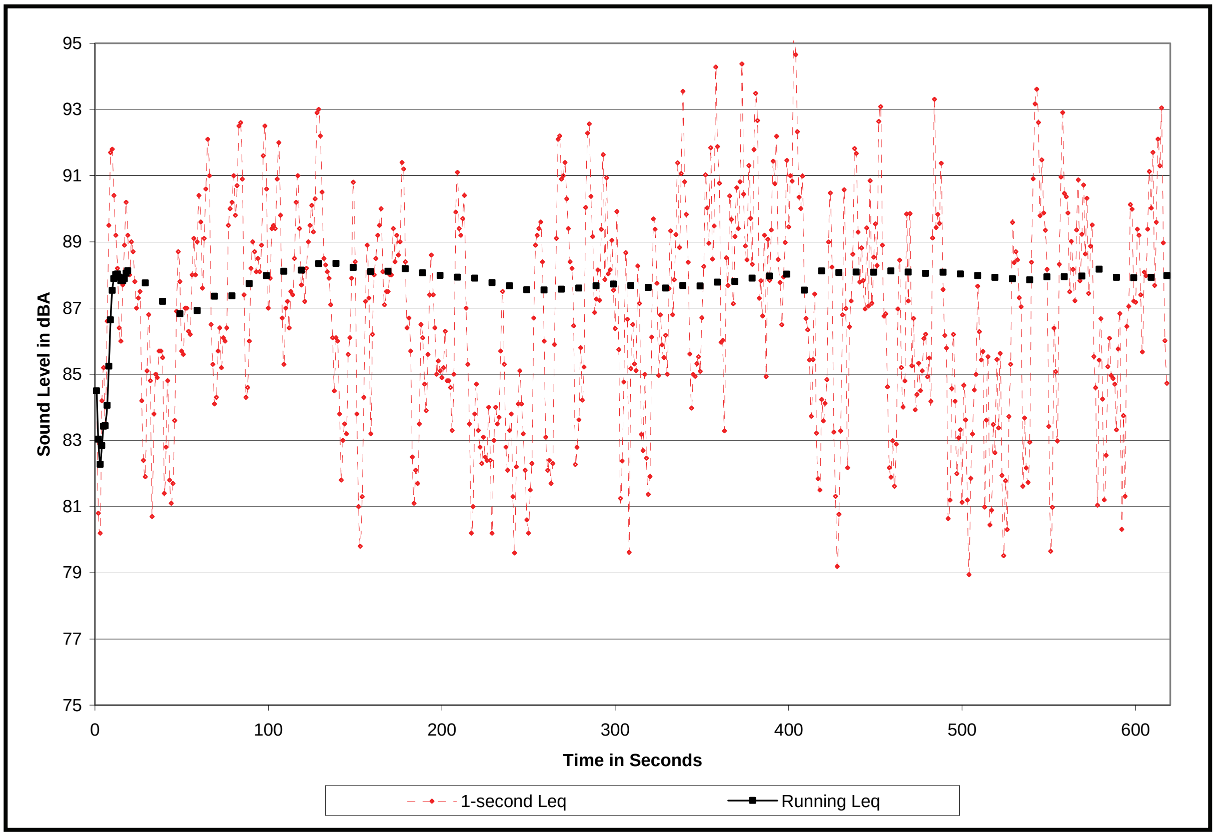


FIGURE 1
Energy Average Leq Noise Levels for Proposed Mercer Island Station

Ashwood/Hospital Light Rail Station

The Ashwood/Hospital light rail station would be located separate and adjacent to the NE 12th Street overpass, approximately 25 feet above I-405. It would be a center platform station, with light rail running on either side of the station platform. On-site noise measurements were performed in the center of the existing overpass on the north side of the NE 12th Street. The dominant noise source was heavy trucks on I-405; however, noise from traffic crossing the overpass was also notable. One-second L_{eq} ranged from 77 to 87 dBA with the overall energy average at this site being 83 dBA L_{eq}.

Noise Modeling

Based on the noise measurements, further analysis was performed for each of the Freeway stations: I-90 Rainier Avenue, Mercer Island and Ashwood/Hospital light rail stations. The models were created using typical daytime traffic volumes and speed from the traffic engineers, a noise model was constructed using the Federal Highway Administration's Traffic Noise Model (TNM). The TNM produces hourly L_{eq} noise levels based on hourly traffic volumes. Because of the constant traffic volumes on major highway like I-90 and I-405, the short-term L_{eq} experienced by patrons at the stations would be the same as the hourly L_{eq}.

Rainier Avenue Light Rail Station Noise Modeling

Because of the high traffic volumes, reflective retaining walls, and close proximity of the traffic to the station, it is unlikely that the noise levels in this area would be able to meet the Sound Transit design guidelines of 72 dBA. Therefore, the 78 dBA 15-minute L_{eq} platforms noise level goal will be applied.

The Rainier Avenue Station noise model was constructed and verified using the measured noise data. Modeled and measured data agreed within +/- 2 dBA Five receivers were located along the platform,

with two at each ends and one in the middle. The modeled noise levels ranged from 84.6 to 85.3 dBA L_{eq}, verifying the accuracy of the model against the measured noise levels but also showing that noise levels would exceed the 78 dBA goal.

Figure 2 shows the potential of ten-foot sound walls added to the outside of the light rail alignment, along the edge the I-90 mainlines. With the walls in place, the noise levels along the platform were reduced by 8.2 to 9.7 dBA along the platform. Figure 2 shows the noise measurement and modeling locations and the approximate locations for the sound walls. Table 1 provides a summary of the noise modeling results before and after adding sound walls.

TABLE 1
Rainier Station Noise Analysis

Receiver No.	Measured Levels	Modeled Levels before Noise Walls	Modeled Levels W/ Noise Walls	Noise Wall Reduction	Wall Details
R1	N/A	85.3	76.4	8.9	10 foot walls along the outside of the tracks, between the rail alignment and the I-90 traffic lanes. Walls could be integrated with the crash barriers to save room.
R2	N/A	85.1	76.9	8.2	
R3	N/A	85.0	75.8	9.2	
R4	N/A	84.9	75.2	9.7	
R5	86.3	84.6	75.4	9.2	

The walls would extend approximately 800 feet west of the Mount Baker Tunnel portals. Actual wall design would be performed during project final design. With noise walls the majority of the platform, the noise levels on the platform are within the 78-dBA noise level and no further noise reducing design alternatives were examined.

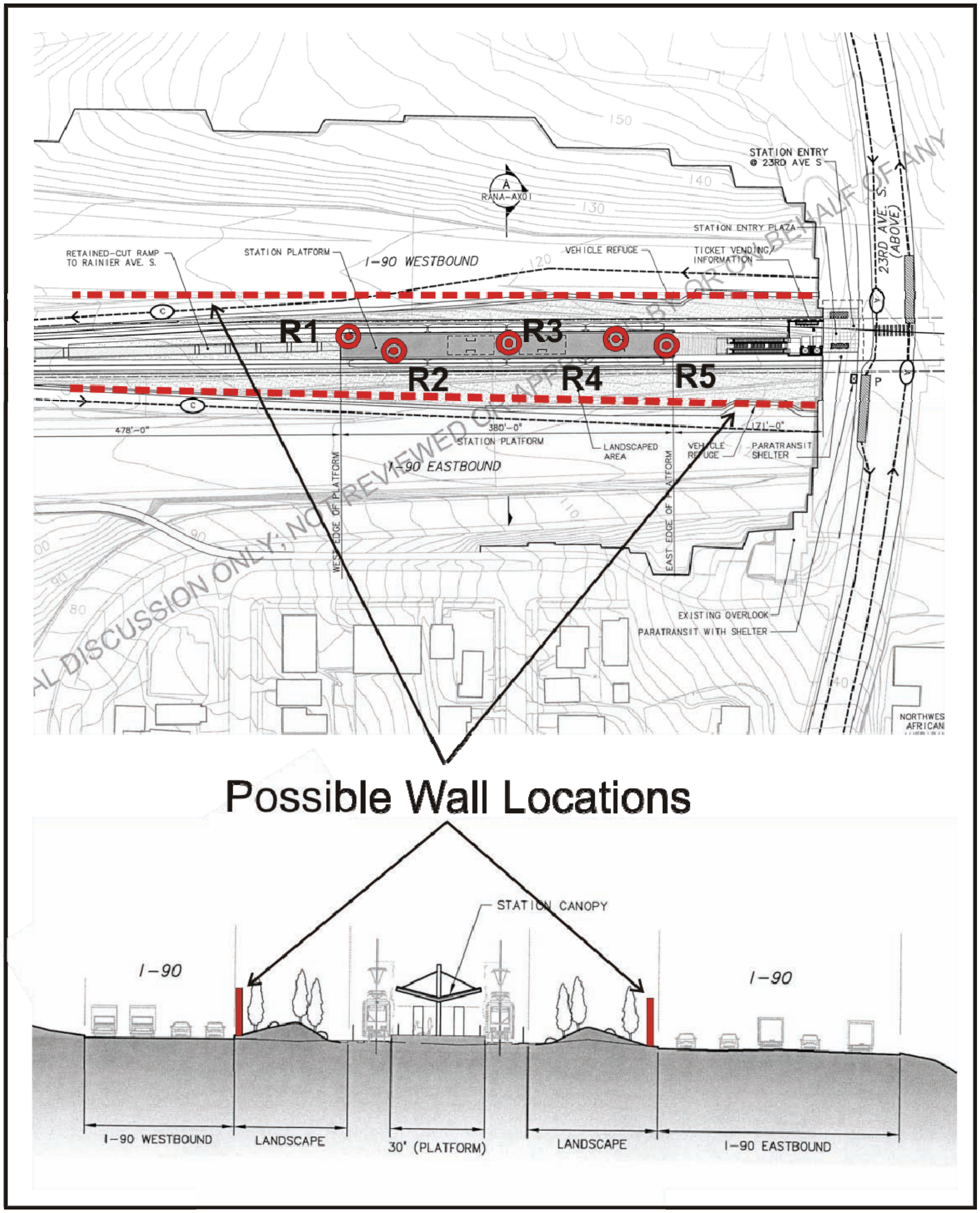


FIGURE 2
Rainier Avenue Noise Monitoring Modeling and Noise Wall Locations

Mercer Island Light Rail Station Noise Modeling

Because of the high traffic volumes, reflective retaining walls and close proximity of the traffic to the station, it is unlikely that the noise levels in this area would be able to meet the Sound Transit design guidelines of 72 dBA. Therefore, the 78 dBA 15-minute Leq platforms noise level goal will be applied

The Mercer Island Station platform model was constructed and verified using the measured noise data of 86 to 88 dBA Leq as reference sound levels, from the measurement taken at R1/M1. Three receivers were located along the platform, Receiver R1/M1, next to the 77th Avenue overpass, and Receivers R2 and R3, located on the proposed station platform. Passengers would only pass through the location of R1/M1 and the purpose of modeling this receiver is to verify the accuracy of the model. Passengers would spend time waiting at the locations of R2 and R3 and therefore the noise effects of traffic concern only those locations. The modeled noise at all three locations was 88 dBA Leq, which verified the accuracy of the model against the measured noise levels.

Figure 3 and 4 show the potential of 10-foot sound walls added on the outside of the light rail alignment, along the edge nearest the train tracks. With the walls in place the noise levels along the platform would be reduced by 10 dBA in the center of the platform, and 7 to 8 dBA towards the end of the platform. Figures 3 and 4 show the noise measurement and modeling locations as well as the approximate locations for the sound walls. Table 2 provides a summary of the noise modeling results before and after adding sound walls.

TABLE 2
Mercer Island Station Noise Analysis

Receiver No.	Measured Levels	Modeled Levels before Noise Walls	Modeled Levels W/ Noise Walls	Noise Wall Reduction	Wall Details
R2	N/A	87.9	77.6	10.3	10-foot walls along the outside of the tracks, with the base of the wall at the same elevations as the tracks.
R3	N/A	87.9	78.3	9.6	

The majority of the platform will have noise levels near or below the 78-dBA noise level goal and therefore no further noise reducing design alternatives were examined.

Ashwood/Hospital Light Rail Station (NE 12th Street above I-405)

Ashwood/Hospital Station noise modeling was also performed using projected 2030 traffic data and speeds for I-405. The modeled noise levels *without* traffic on NE 12th included in the model was 81 dBA L_{eq} at outer edge of the station where the light rail tracks would be installed. For patrons on the station platforms, noise levels ranged from 75 to 78 dBA L_{eq}. The lower noise levels on the platform are due to the noise-reducing effects of the light rail alignment and bridge over I-405. Because the noise levels at the platform are projected to remain below 78 dBA L_{eq}, no noise-reducing design improvements were investigated.

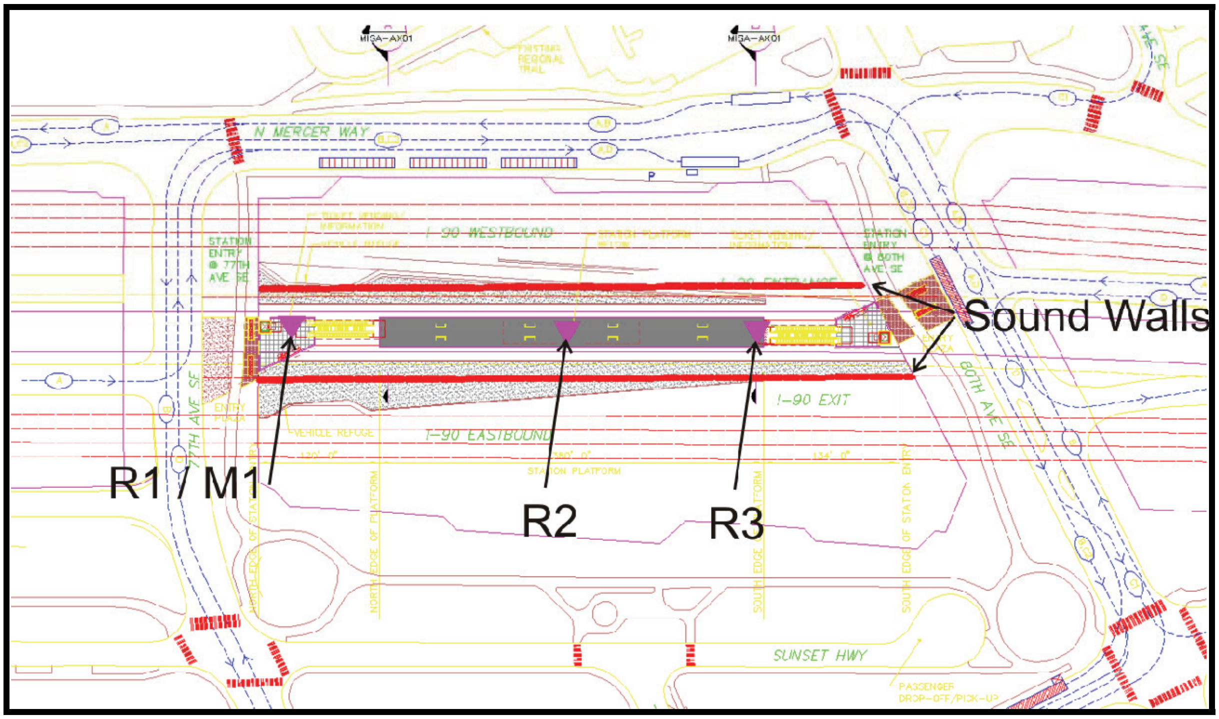


FIGURE 3
Mercer Island Station Noise Monitoring Modeling and Noise Wall Locations

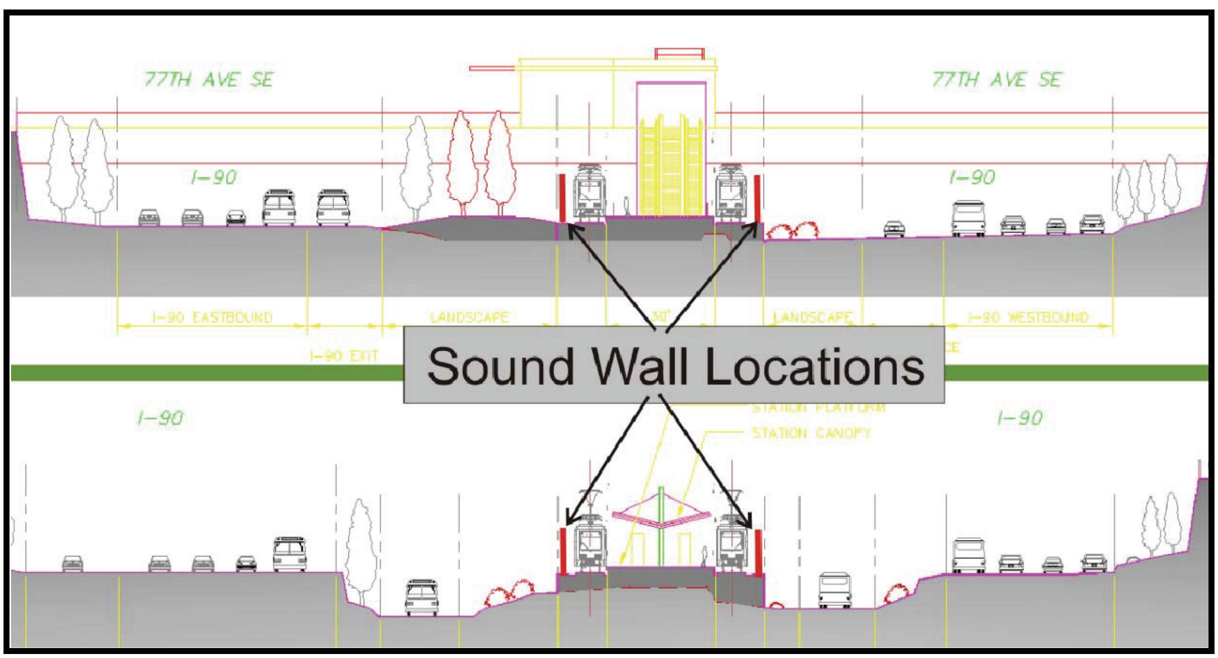


FIGURE 4
Mercer Island Station Noise Walls as Viewed from I-90

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Prepared for:	Jodi Ketelsen
Prepared by:	Michael A. Minor
Date:	Monday, November 10, 2008
Subject:	Noise Level Projections
Project:	Proposed Children's Hospital

This memorandum summarizes the noise level projections for the new Children's Hospital on 116th Ave NE, just north of NE 12th Street. The noise projections assume the following:

1. Distance from the LRT alignment to the building is approximately 100 feet, the distance from the proposed gates is approximately 150 feet and 200 feet (may be further).
2. Speed of the train was modeled at 35 MPH as the worst case scenario.
3. Reference noise levels for typical crossing bells are 72 dBA Lmax at 50 feet (86 dBA at 10 feet). The bells run for approximately 20 seconds.
4. The plan is for one train to pass in either direction every 7 mins in the evening hours including after 10 PM until 1AM and up to one train every 4.5 minutes in the day time.
5. The existing Ldn for traffic near the site is 68 dBA as a conservative (based on 2 dBA lower then the intersection noise level measurement at NE 12th and 116th Avenue NE due to shielding and distance) and the FTA criteria is 63 dBA Ldn for moderate impact and 68 dBA Ldn for severe impacts.

Based on the above information, the noise from LRT operations is predicted at 61 dBA Ldn at the closest point at the proposed hospital and the noise from the crossing bells is predicted at 53 dBA for the same point. The total Ldn is projected at 62 dBA Ldn and no noise impacts are projected.

It is anticipated that modern insulation and noise reduction due to double windows, it is unlikely that noise will be auditable inside the building assuming that the windows are non-open-able.